Development of the interferometer module for DECIGO Pathfinder

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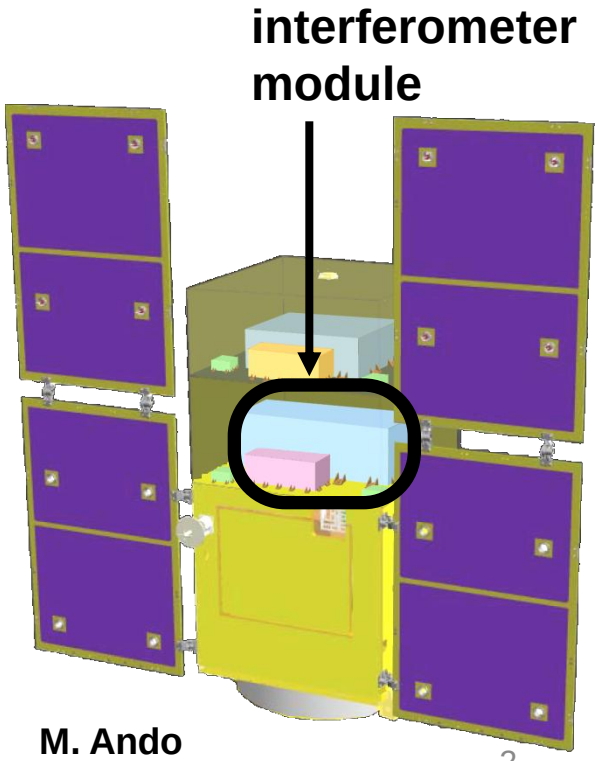
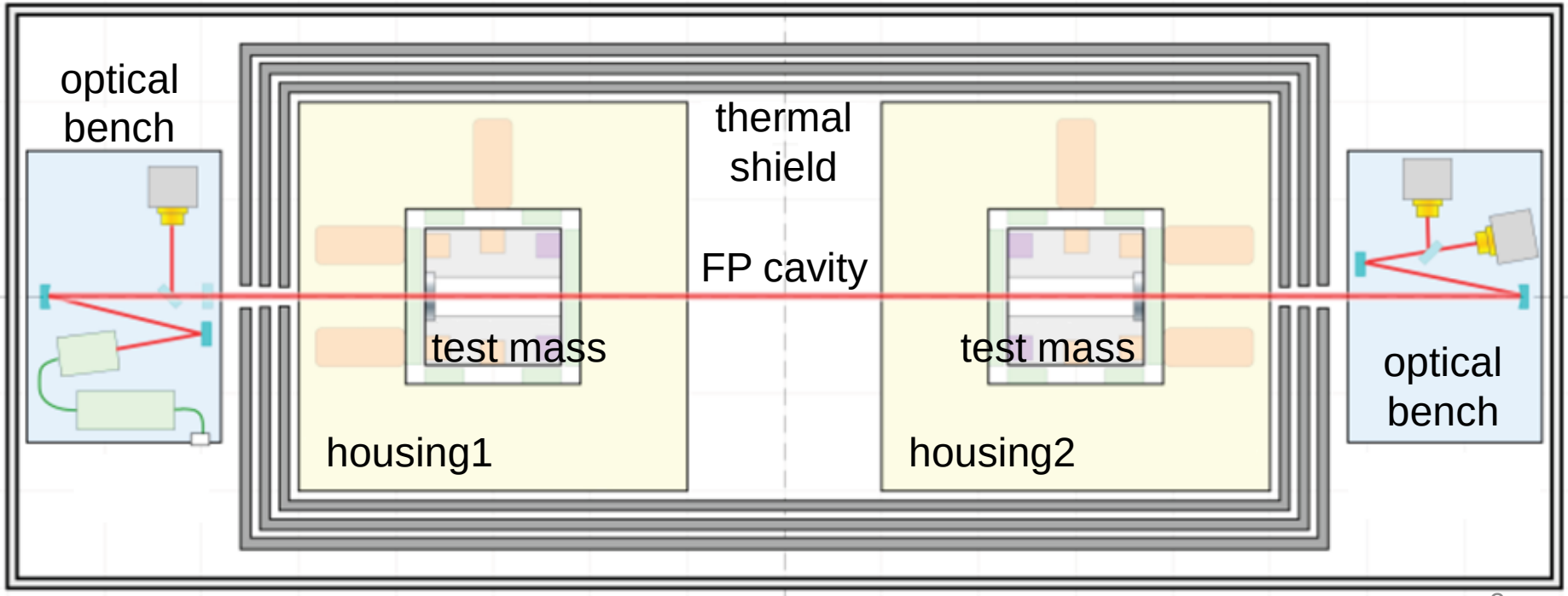
DECIGO Pathfinder

- the first milestone mission for DECIGO
- carries stabilized laser source and Fabry-Perot cavity
- observe GW and measure gravitational field of the Earth
- earliest possible launch: ~2015-16
- what I do: assemble BBM of the interferometer module and verify the operation



Interferometer Module

- 2 monolithic optical benches, 2 test masses, thermal shields
  +servo system(PDH, WFS)

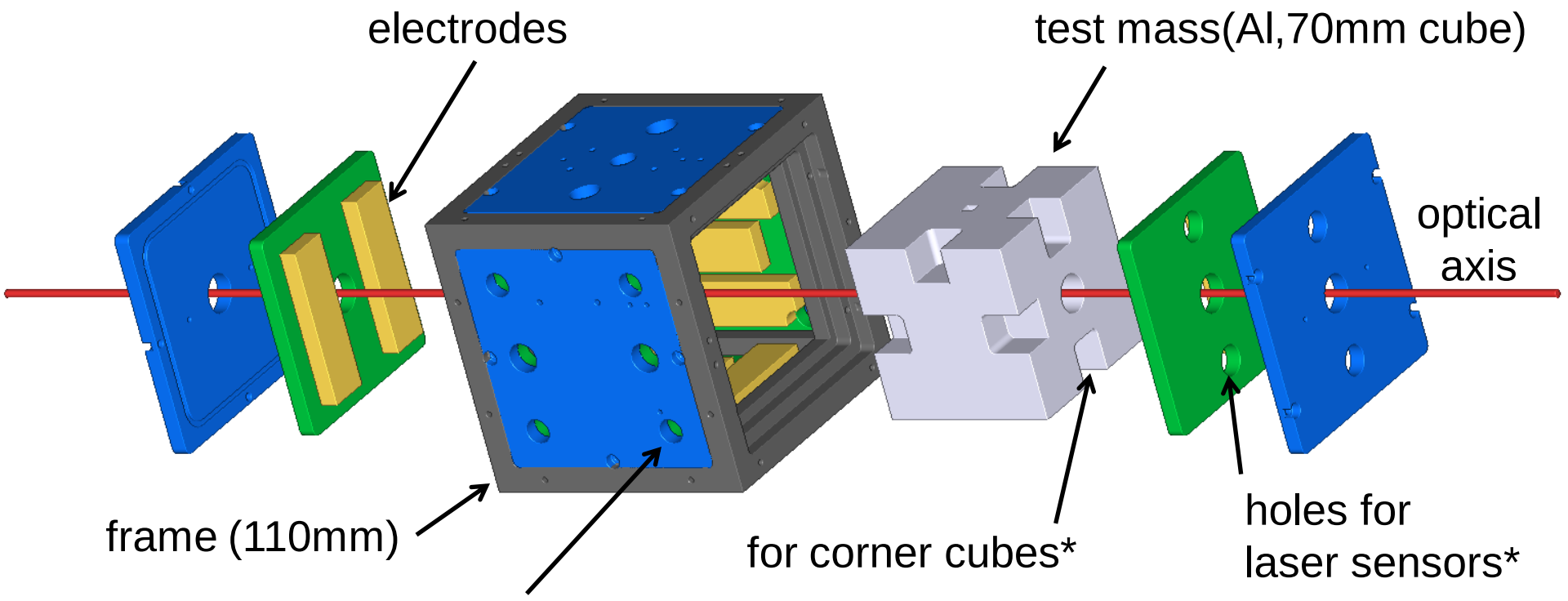


interferometer module(800×300×300mm)

thermal shield

Mass Module

- surrounded by 12 electrodes
  work as electrostatic sensors/actuators



*see poster by A. Shoda (#59)

Overview of the BBM Experiment

- aim: test the operation on the ground
  - components are the same scale as BBM
  - realistic digital servo system
    same FPGA board used for the prototype of SWIMμv*

*GW detector launched in 2009
see poster by W. Kokuyama (#31)

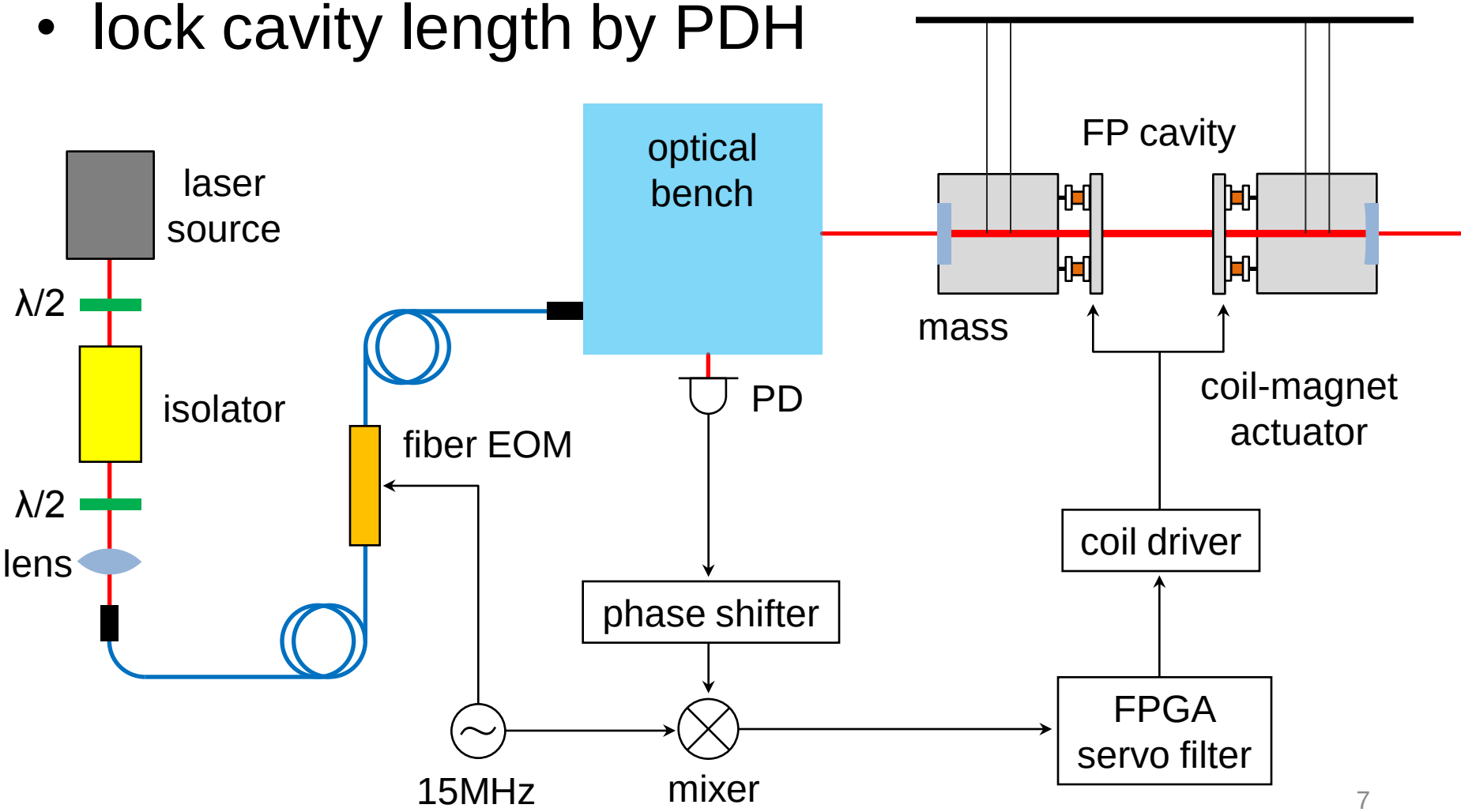
- what's different?
  - test masses are suspended
    the shape of the test mass is slightly different from the original BBM

Status of the BBM Experiment

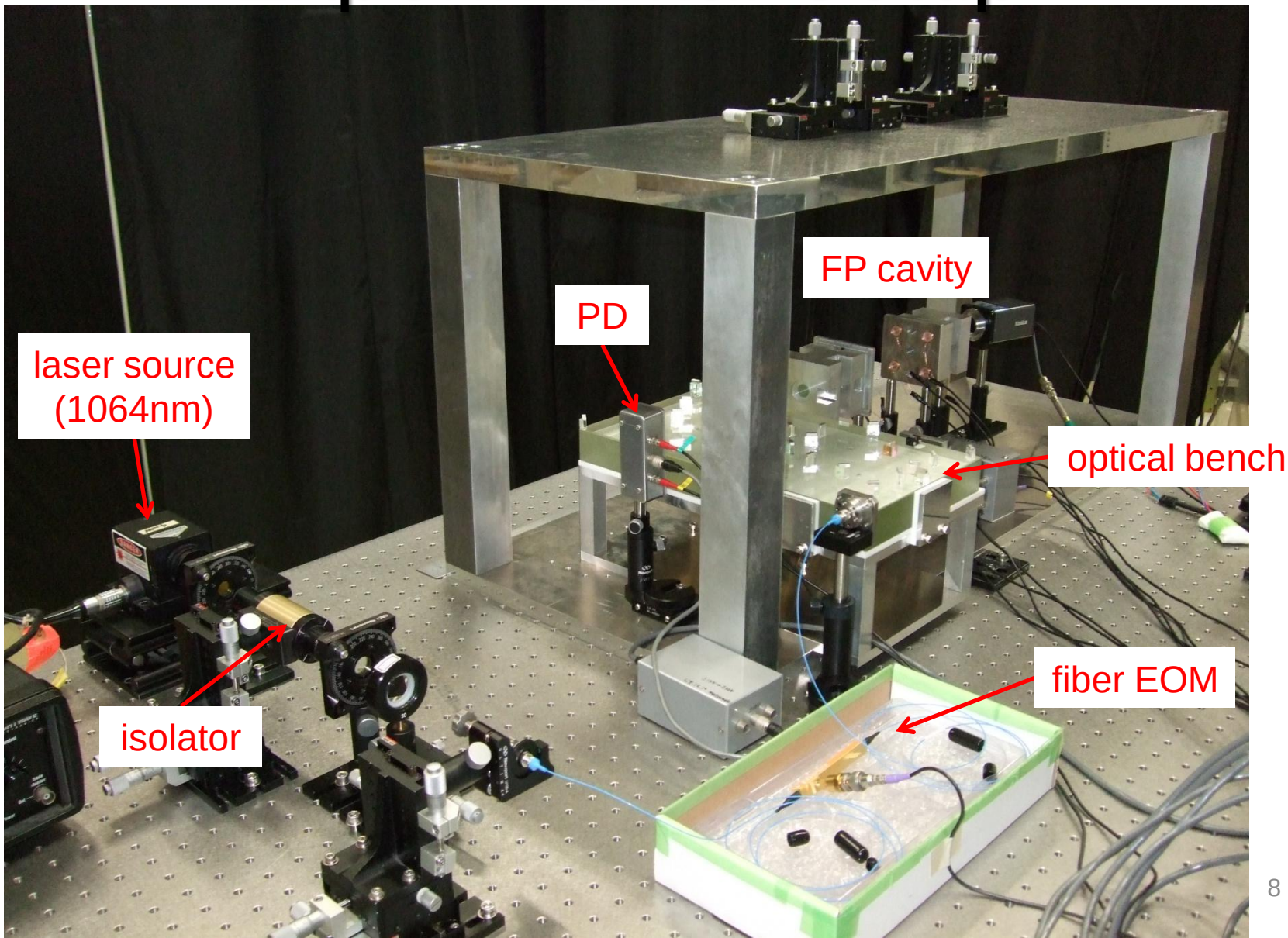
- ✓ making the suspension system
- ✓ installing the monolithic optical bench
  - ✓ fiber injection
- ✓ cavity length control by PDH
  - ✓ coil-magnet actuators first
  - ✓ digital servo using FPGA
- alignment control by WFS
  currently working on QPD circuits
- electrostatic actuators, modularization
- thermal shields, vacuum ……

Experimental Setup

- lock cavity length by PDH



Experimental Setup



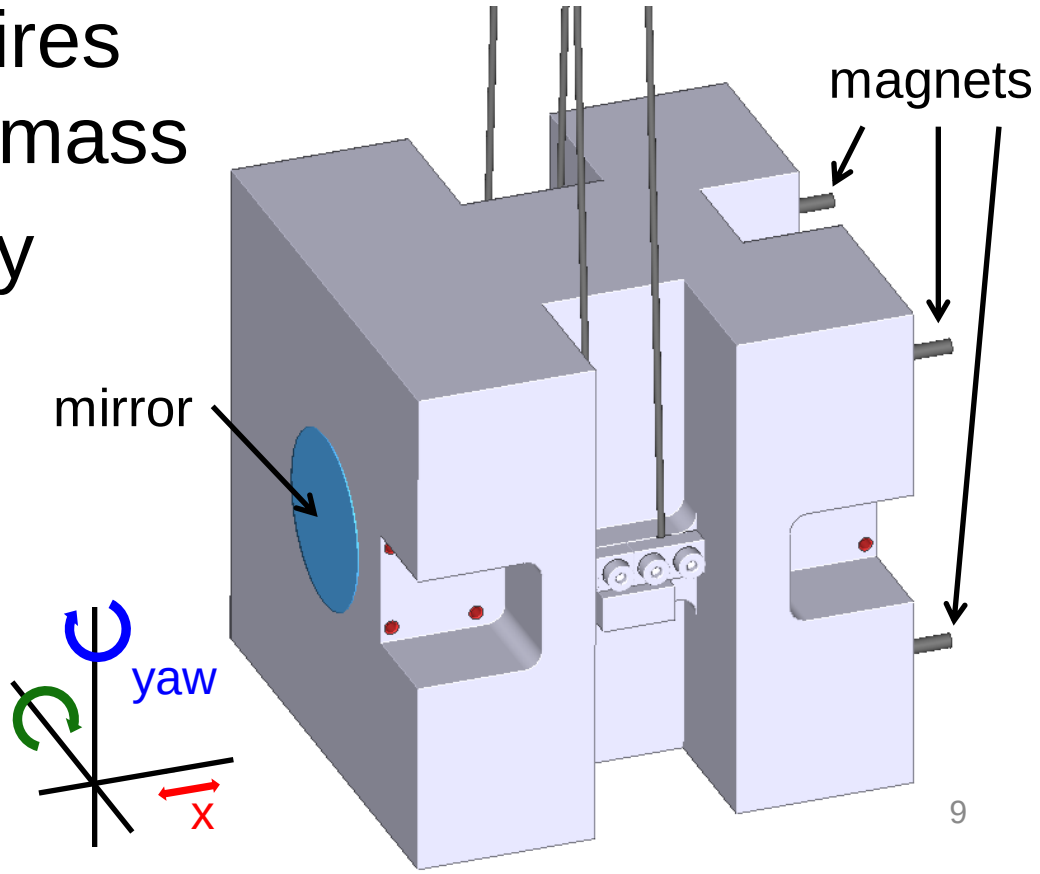
Suspension of the Test Mass

- aluminum, 70mm cube, 0.71kg
- 4 magnets for actuation
- suspended by 4 wires near the center of mass
- resonant frequency (calculated)

$$f_{\mathrm{x}} = 0.91\,\mathrm{Hz}$$

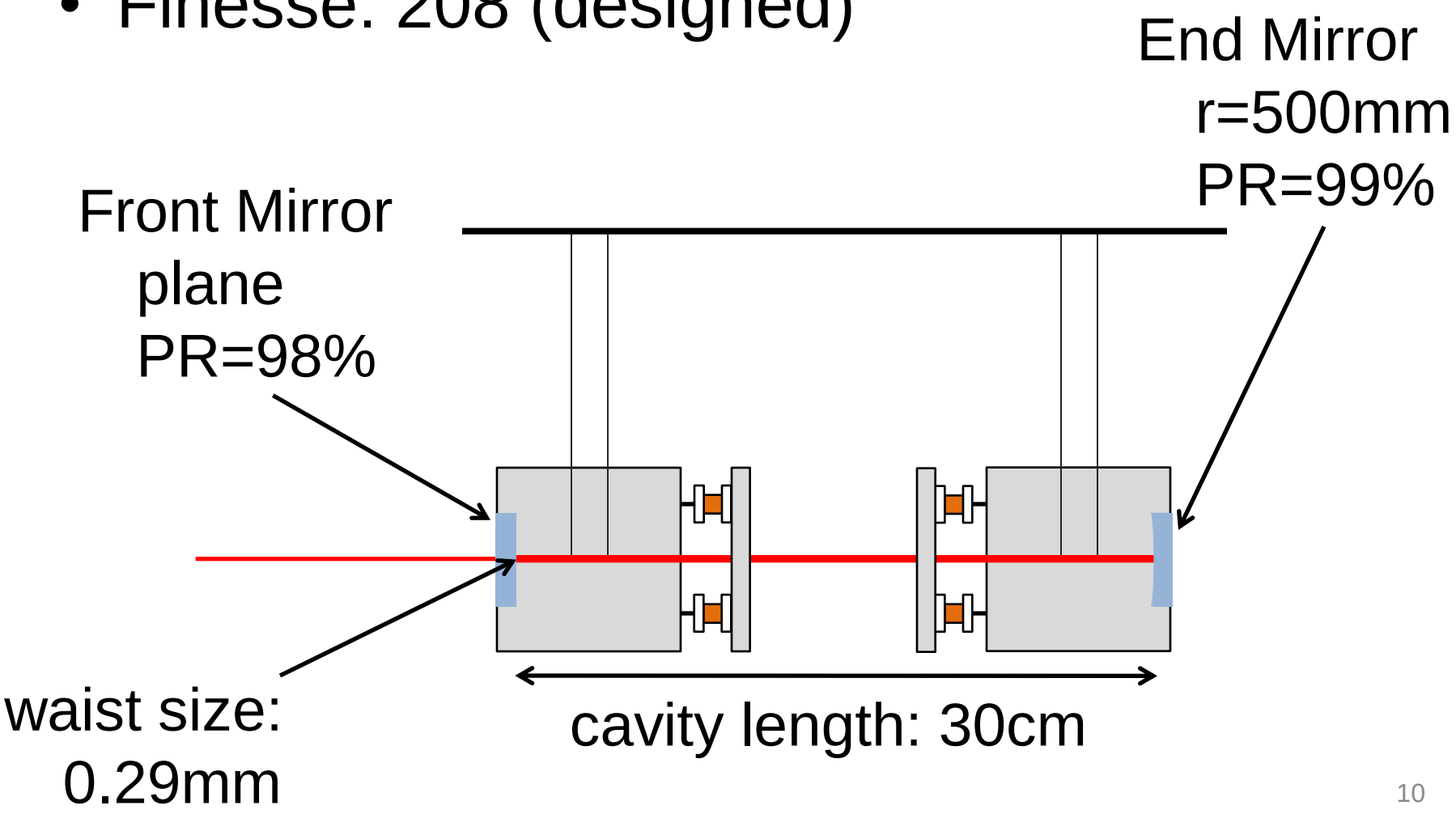
$$f_{\mathrm{pitch}} = 3.24\,\mathrm{Hz}$$

$$f_{\mathrm{yaw}} = 0.24\,\mathrm{Hz}$$



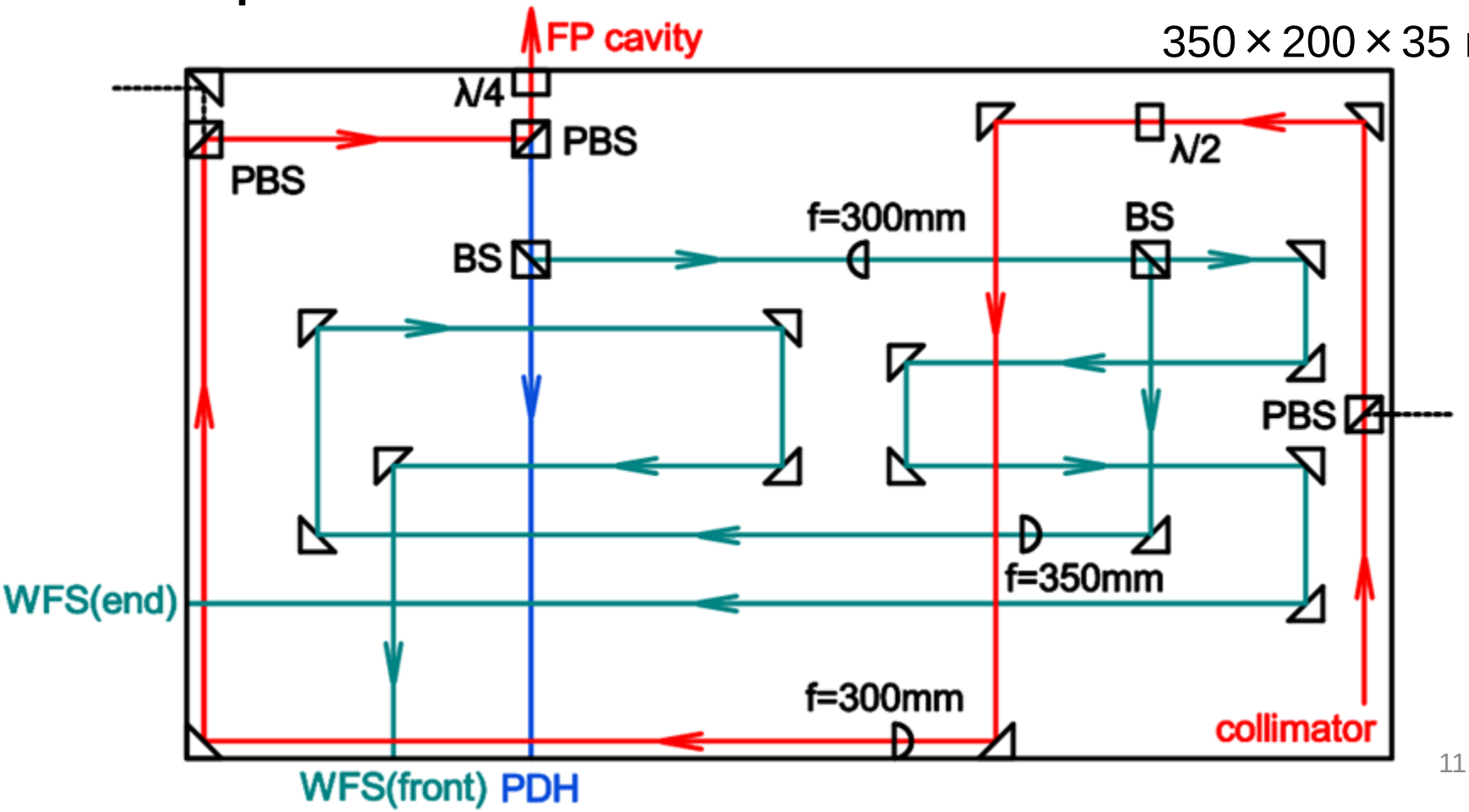
Fabry-Perot Cavity

- Finesse: 208 (designed)

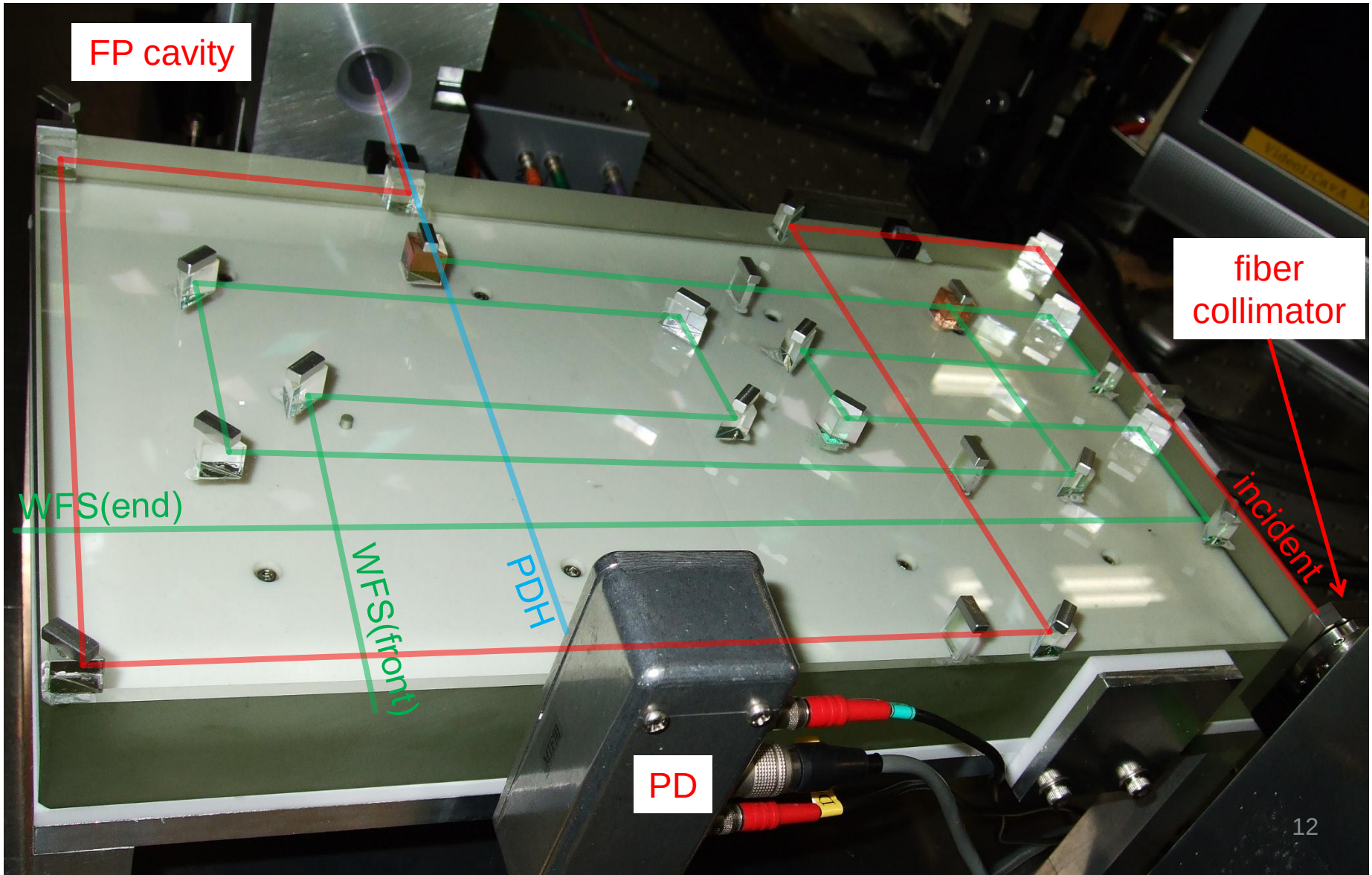


Optical Bench

- Pyrex glass base plate with the optical components silicate bonded to it

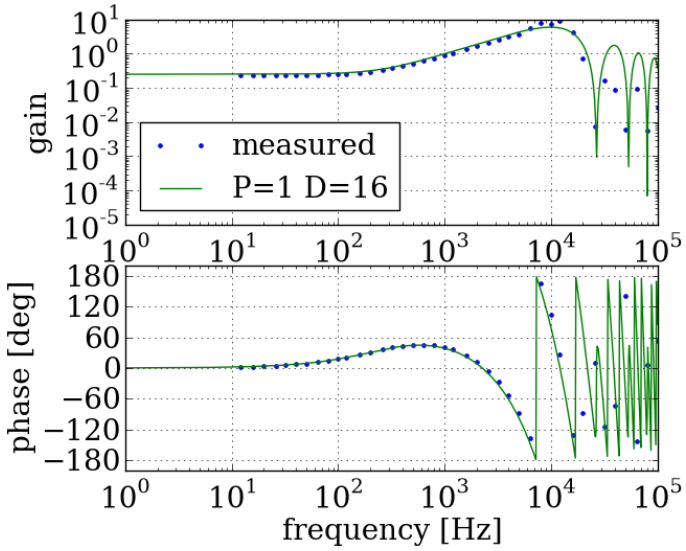


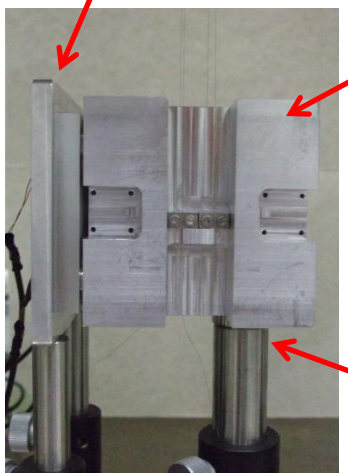
Optical Bench

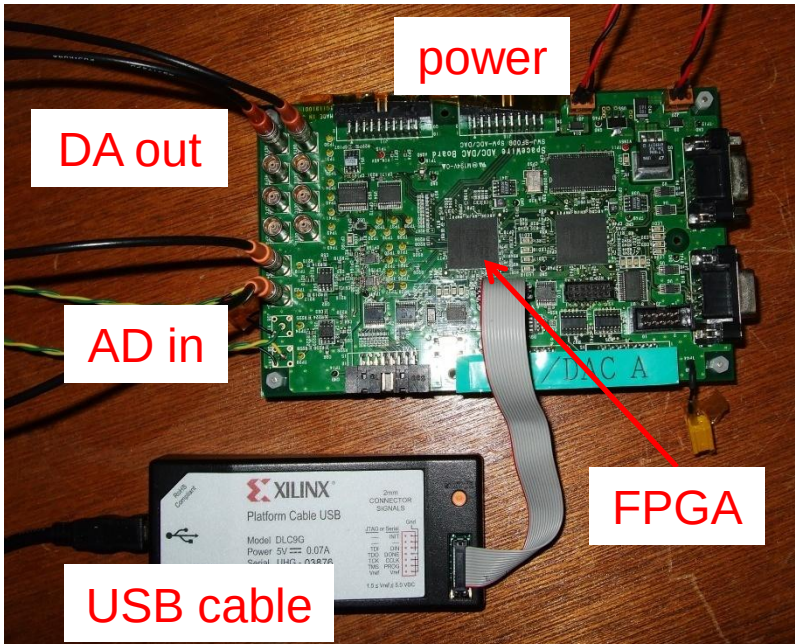


Servo System

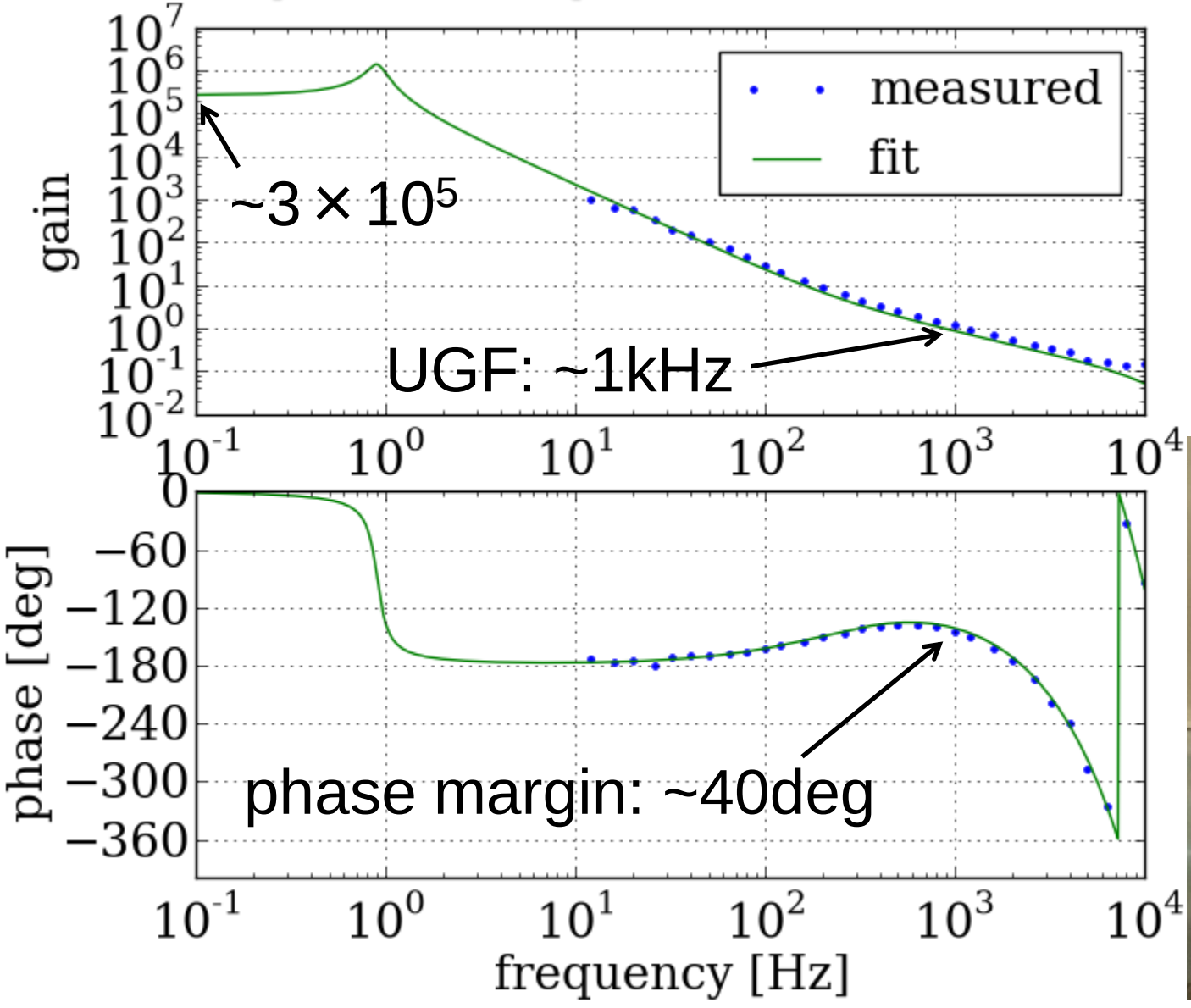
- digital control by FPGA
  same board used for the prototype of SWIMμv
  f_s=26.8kHz, PD servo
- coil-magnet actuators





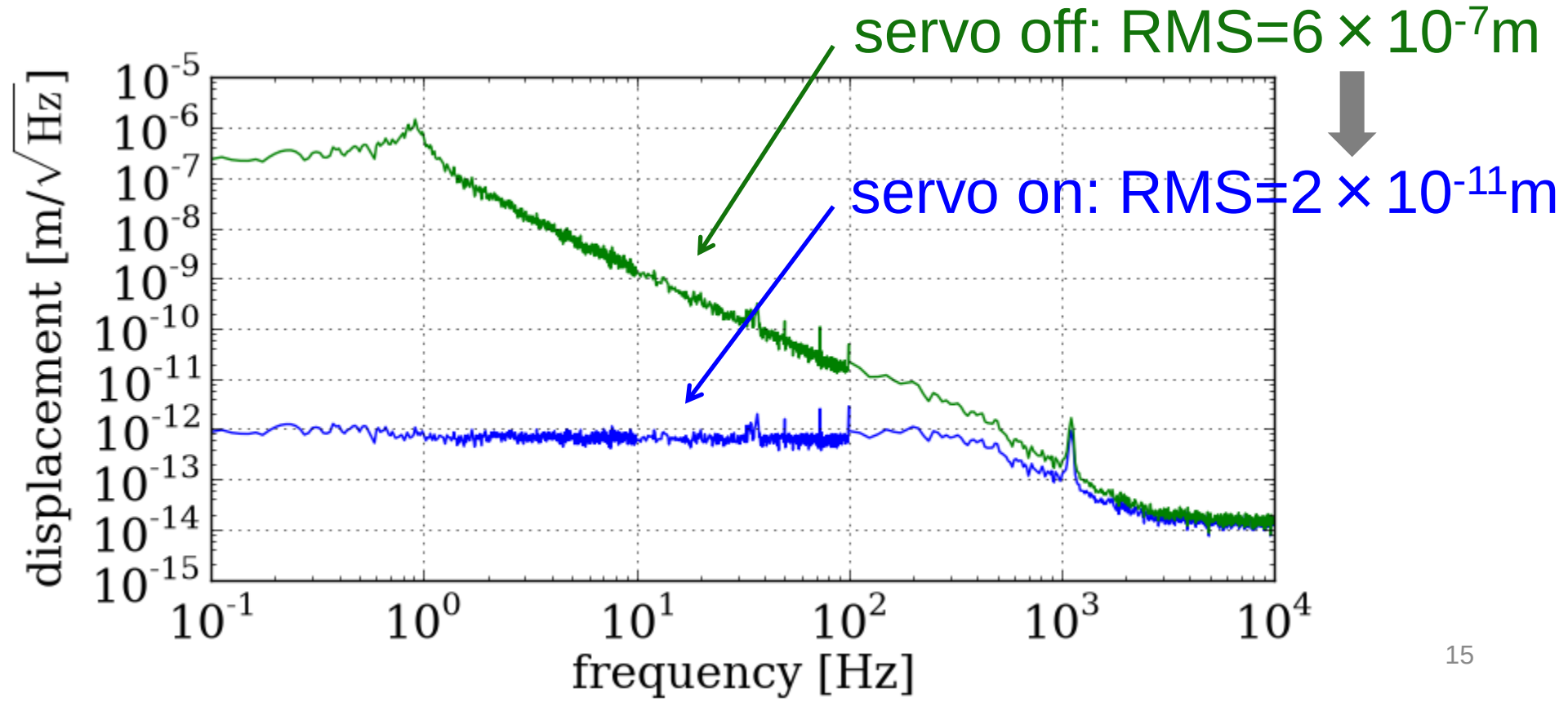


Openloop Transfer Function



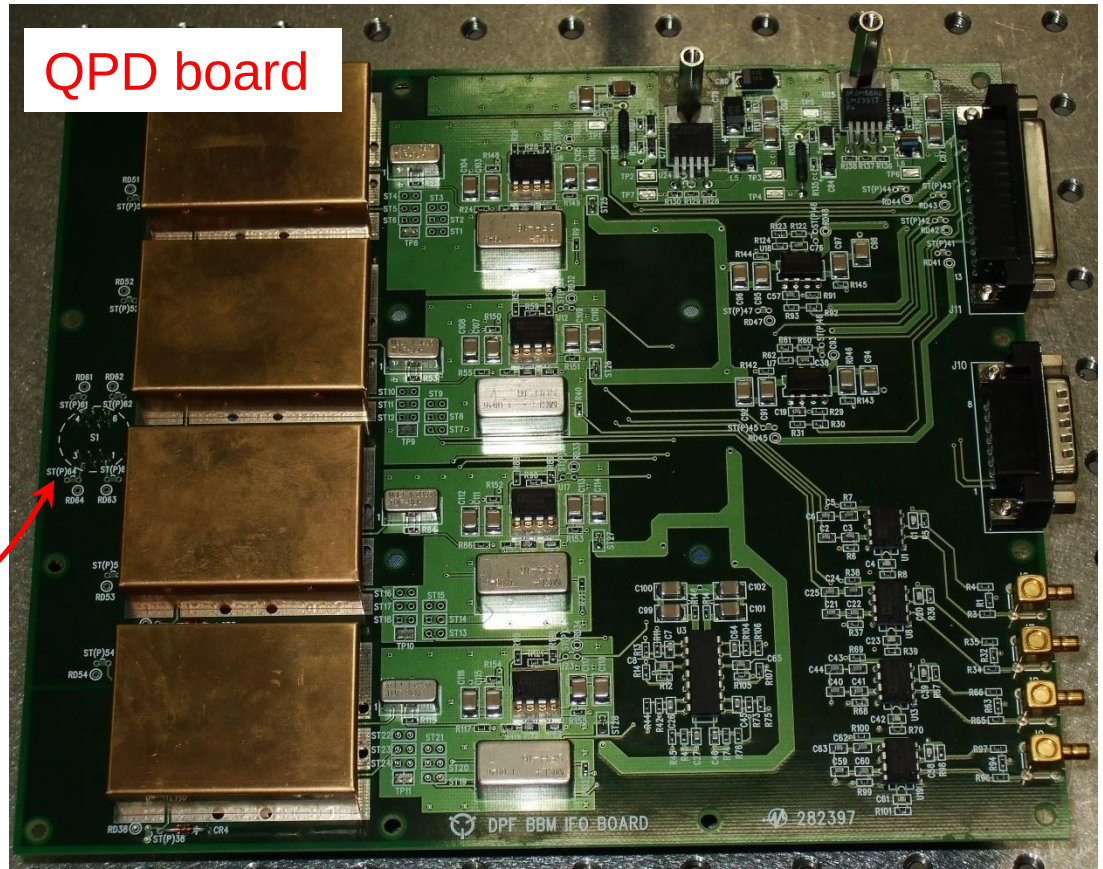
Cavity Length Noise Spectra

- spectrum when the servo is turned off(green) is estimated by openloop calibration



Next Step

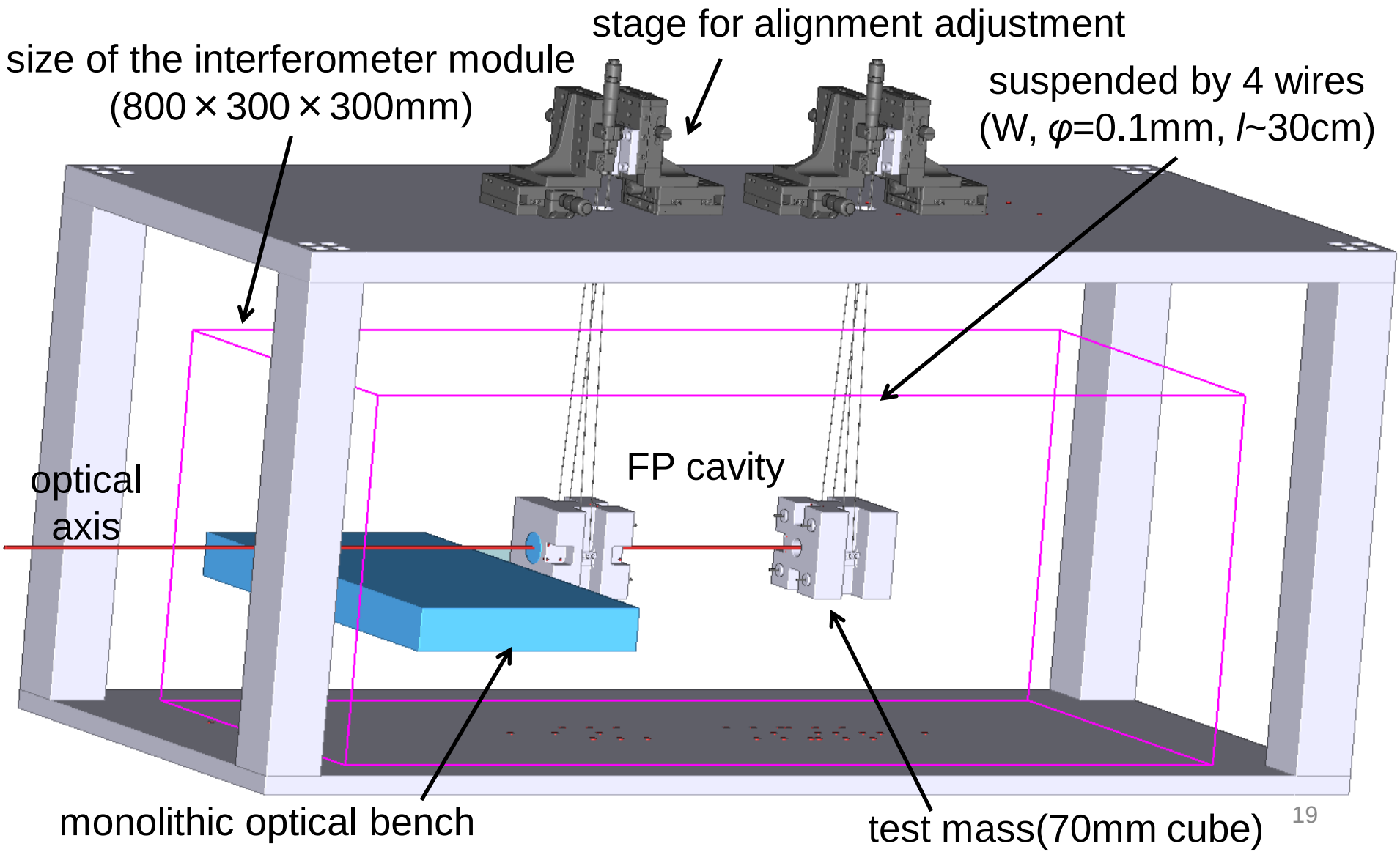
- install QPDs
- alignment control by WFS



Summary

- DPF is the first milestone mission for DECIGO
- BBM experiment is ongoing
- succeeded in the cavity length control
  monolithic optical bench
  digital control using FPGA
  coil-magnet actuators
- next step is to install QPDs and start the alignment control

Suspension Frame



FPGA

- Field Programmable Gate Array
- sampling frequency: 26.8kHz
- PD servo

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fb[k]=P*er[k]+D*(er[k]-er[k-1])
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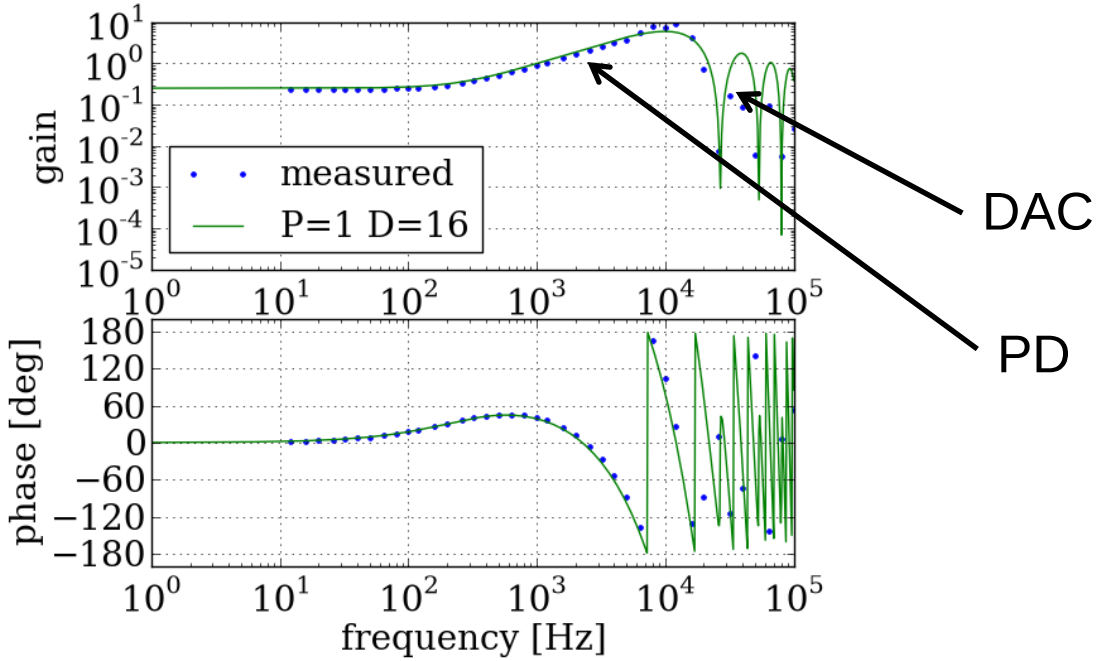

Actuation Efficiency

- measured using photo-sensors