2ND PACMAN WORKSHOP
Debrecen, Hungary
Monday 13th June to Wednesday 15th June 2016

Active isolation of an extended structure with fused sensors

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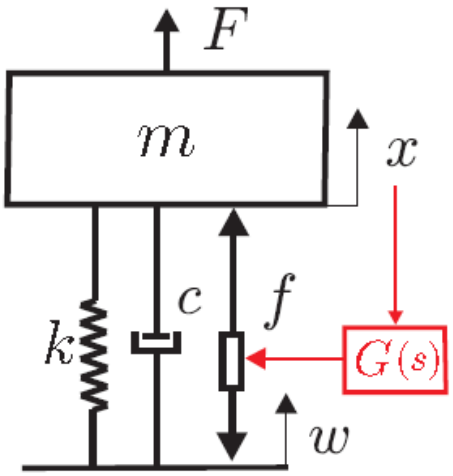
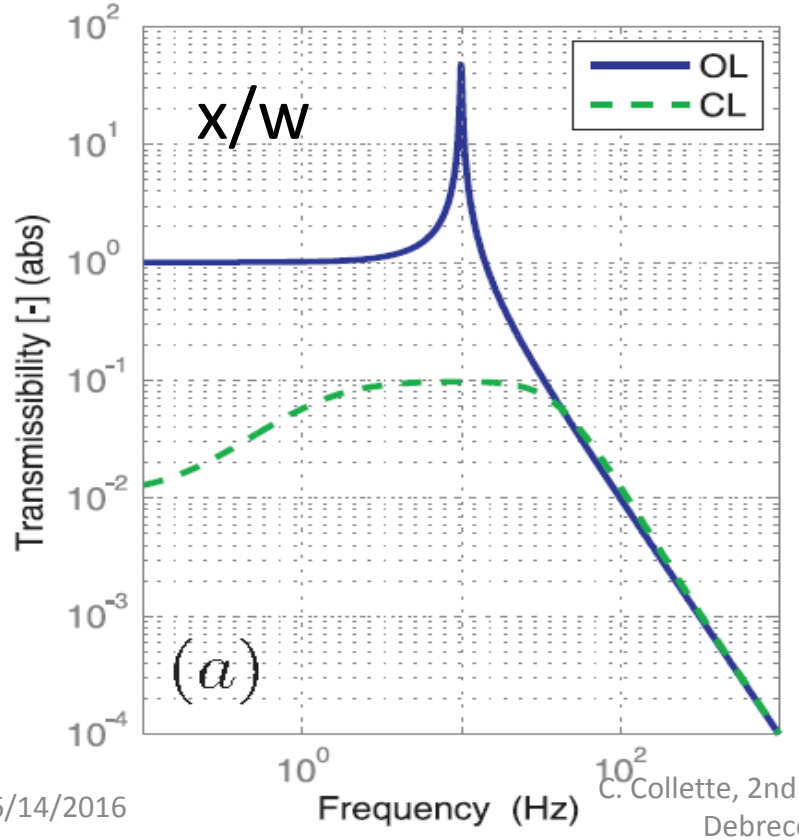
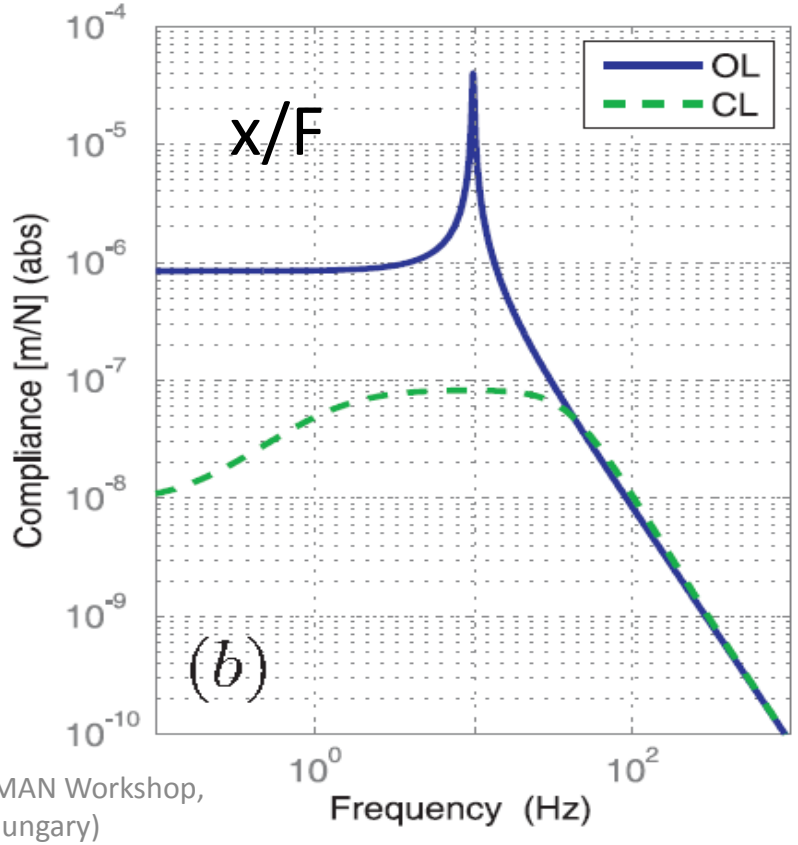
LSC LIGO Scientific Collaboration

beams



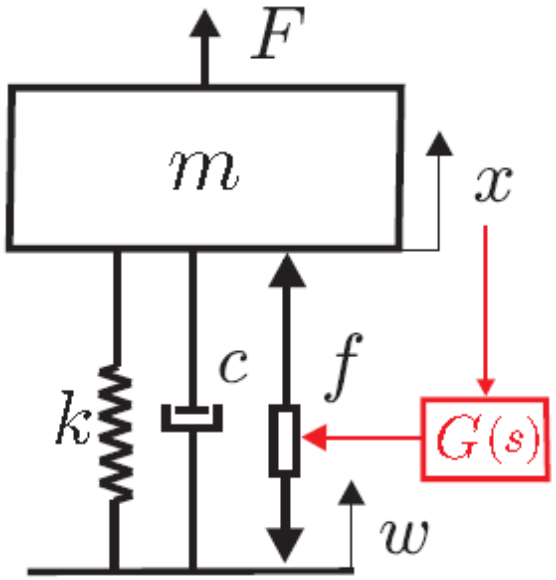
Active isolation : Inertial control

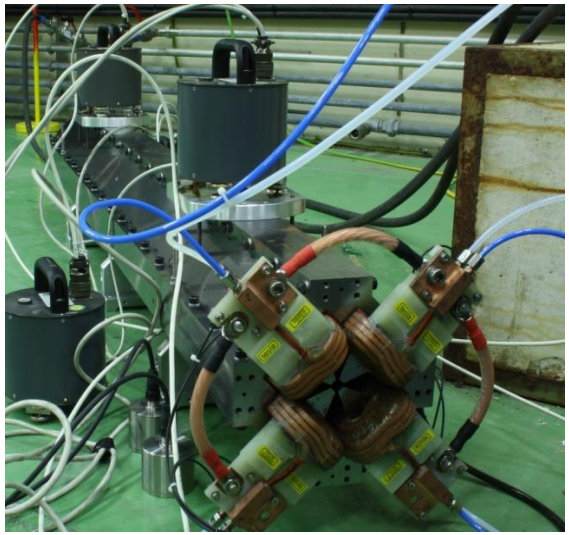




Dream

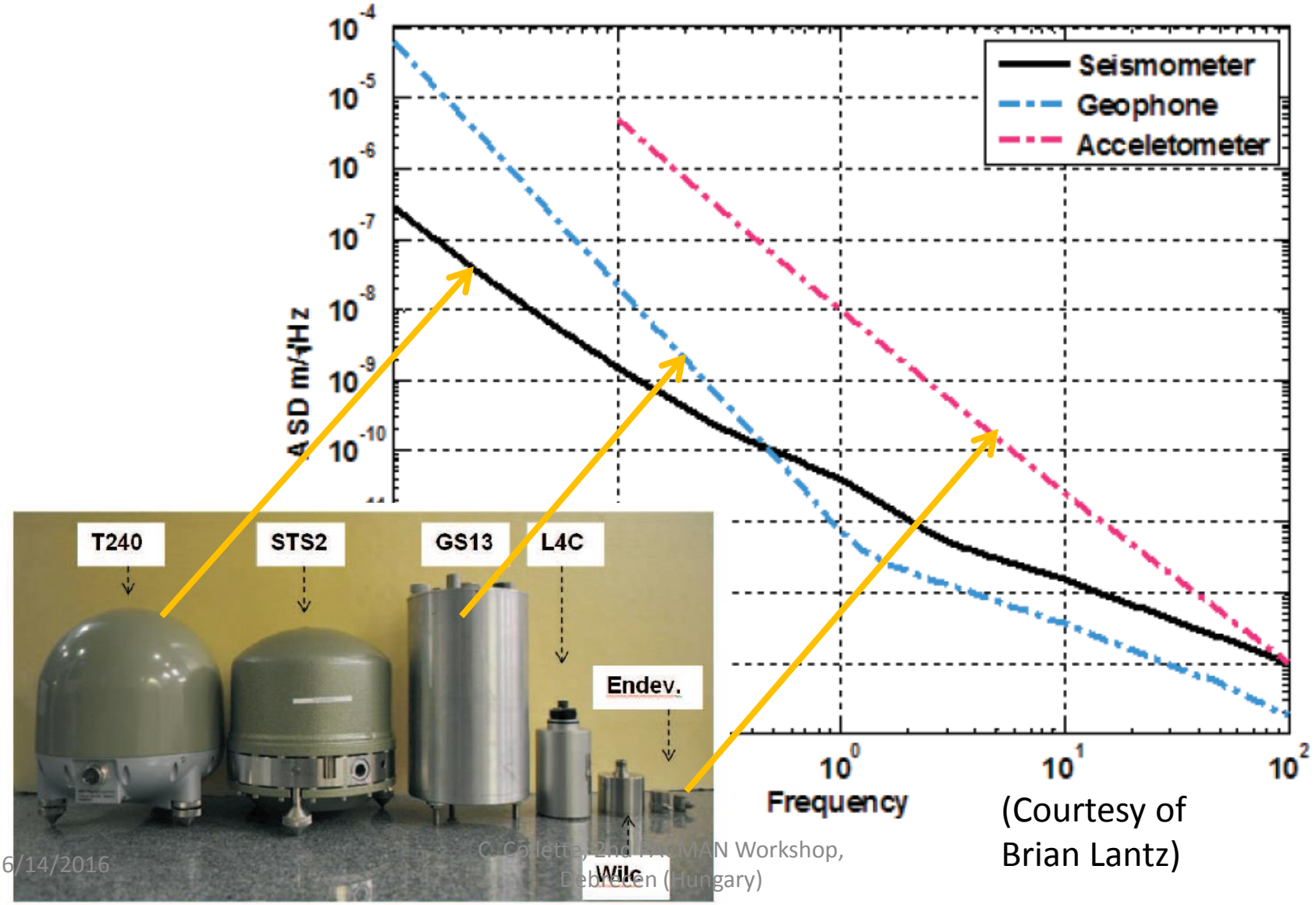
Reality



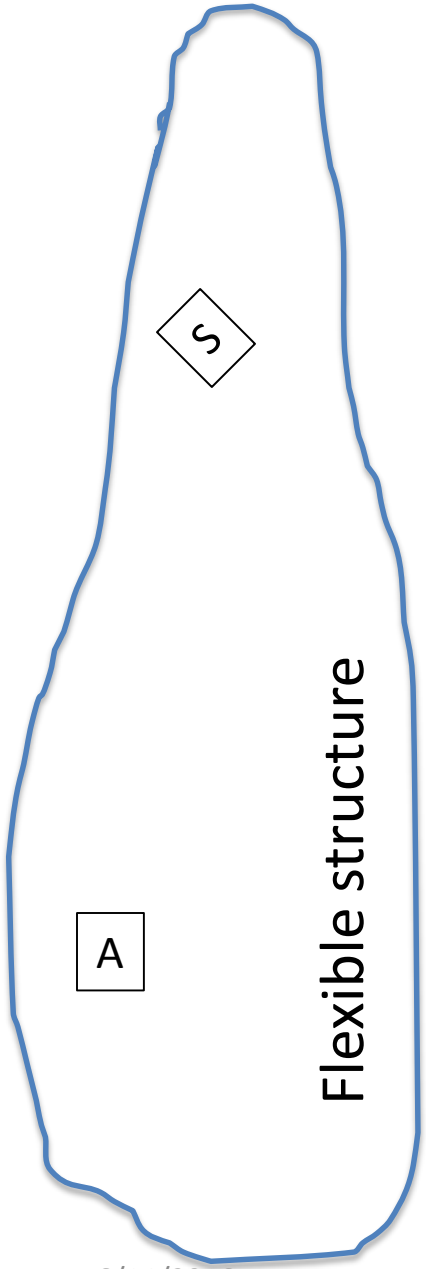


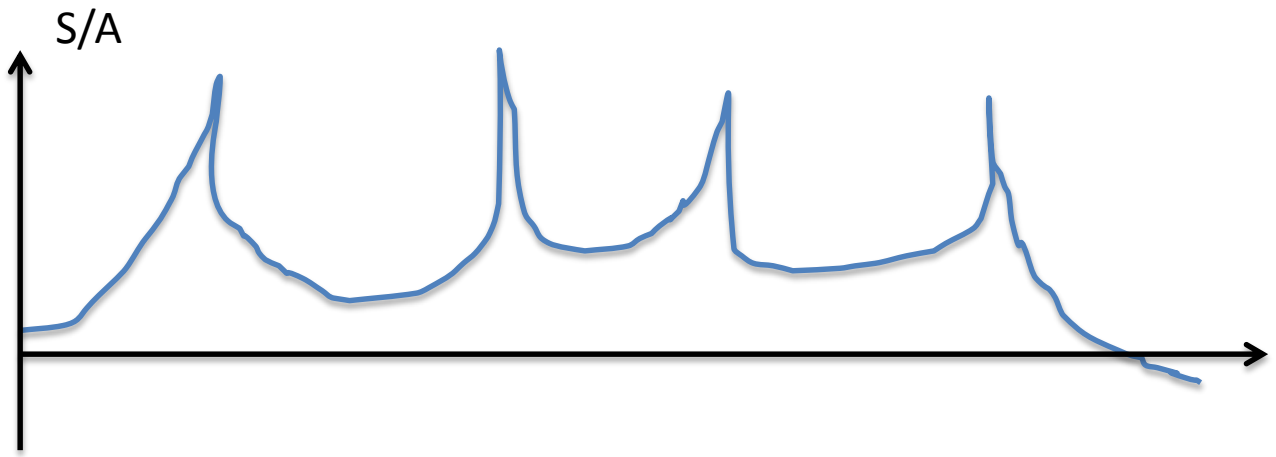
- How to measure x ? (Peter & Jennifer's talk)
- Architecture: where are the sensors/actuators ?
- How to control ?

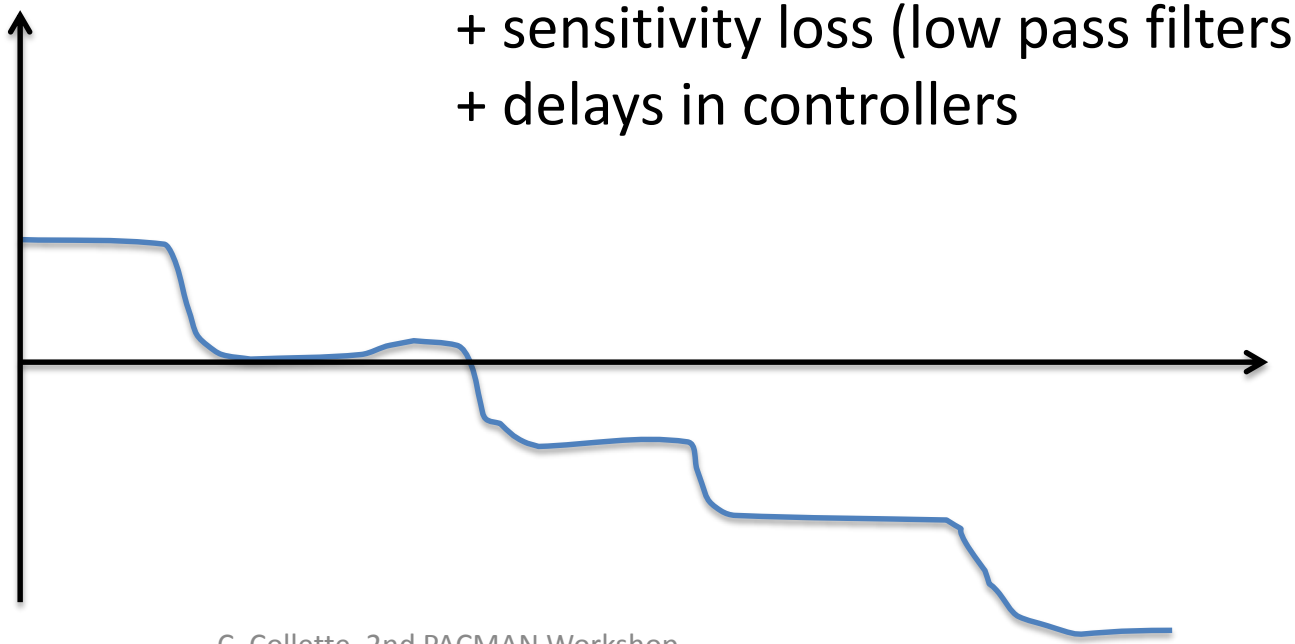
Sensor size and noise



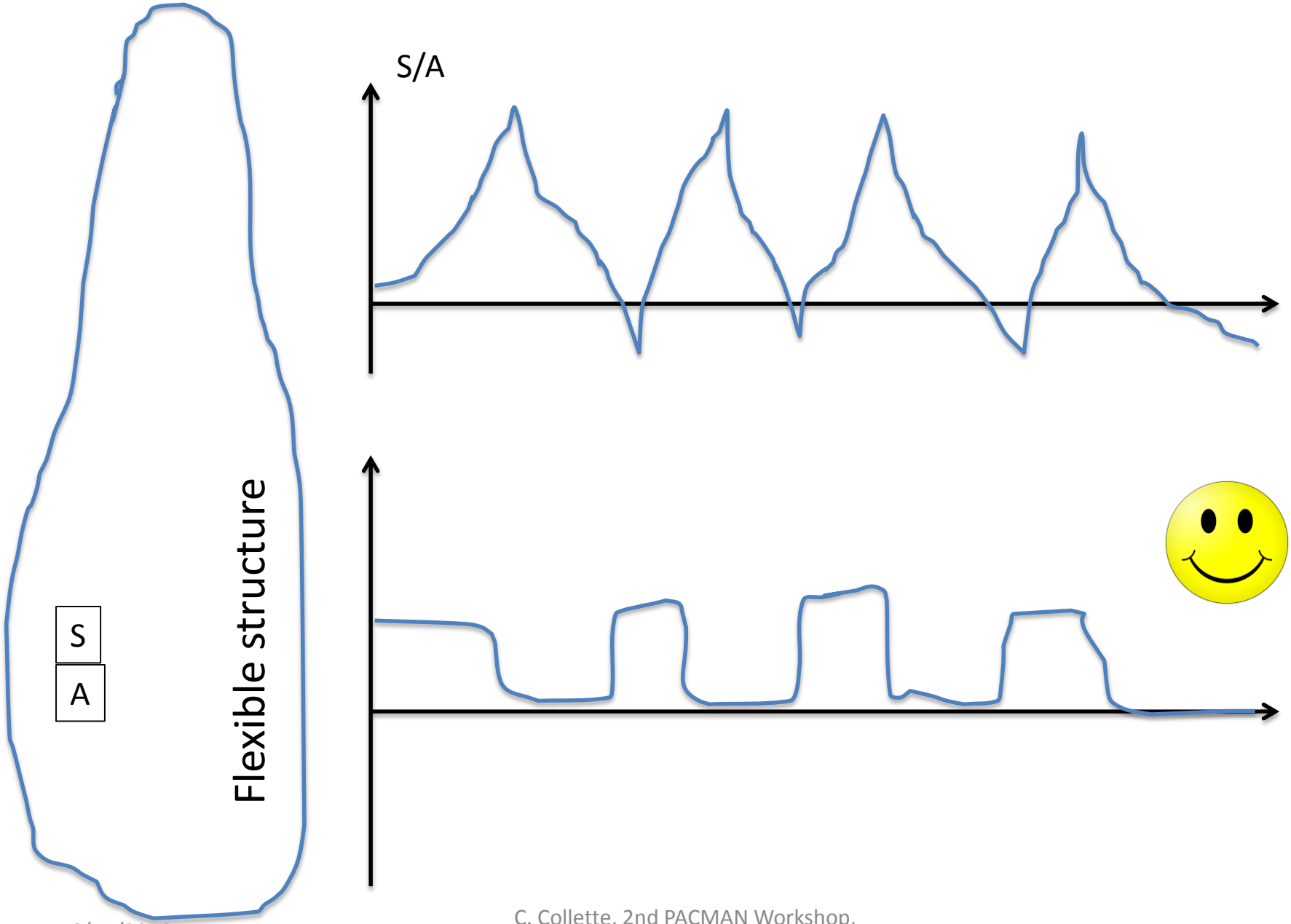
(Courtesy of Brian Lantz)







+ sensitivity loss (low pass filters)
+ delays in controllers


S/A
Flexible structure
S
A

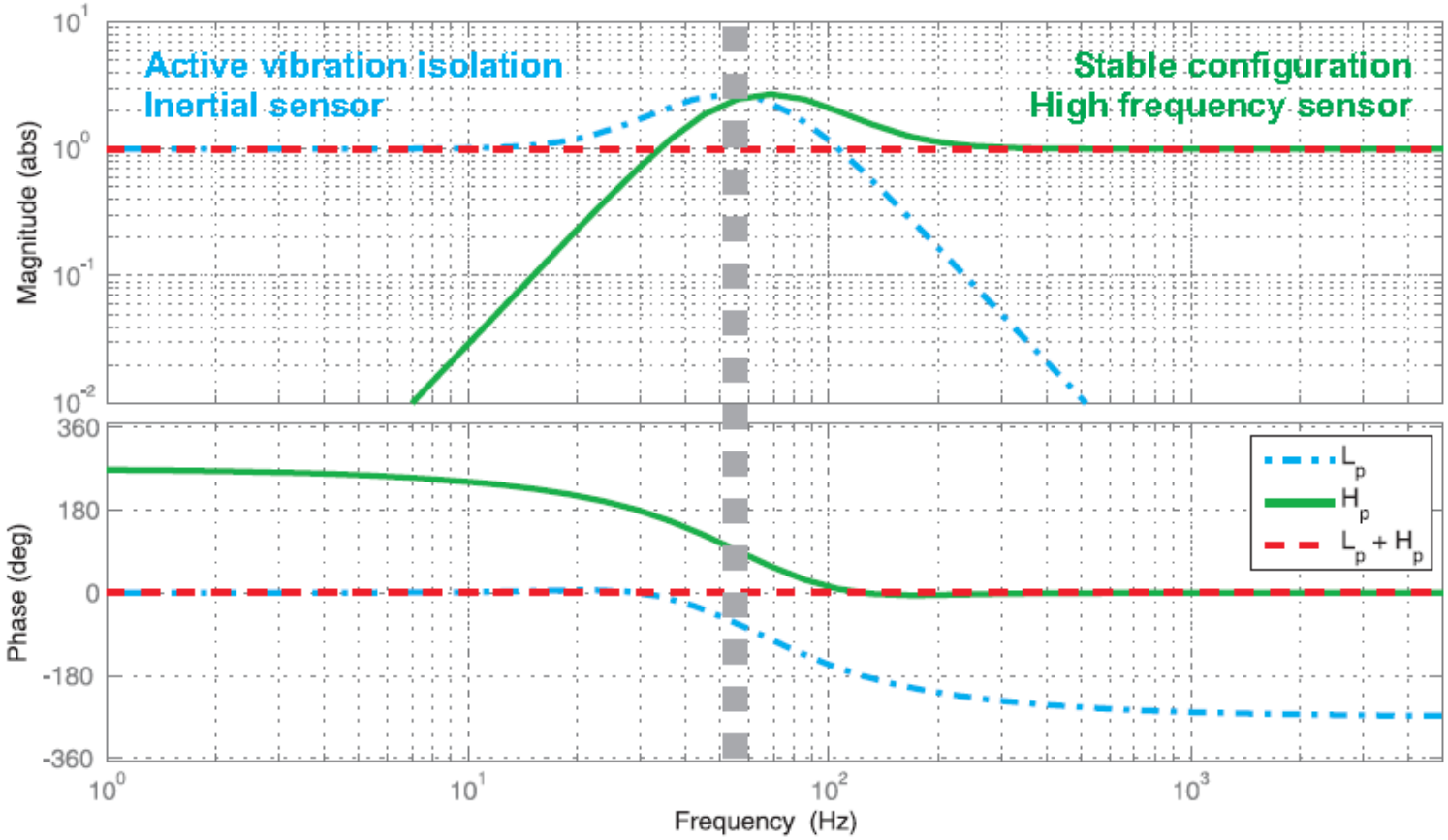
Design constraints and control bandwidth

Low frequency isolation ➔ Large seismometer

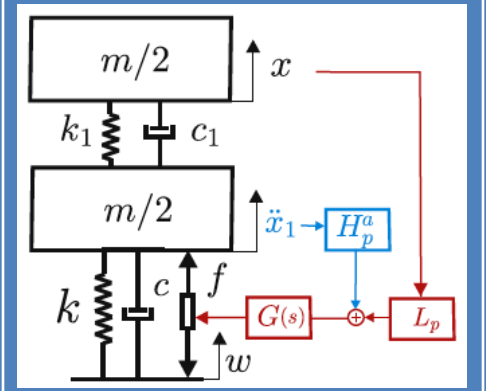
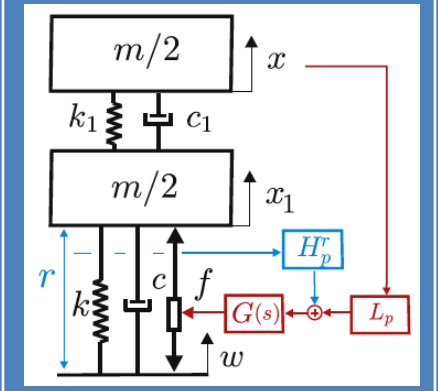
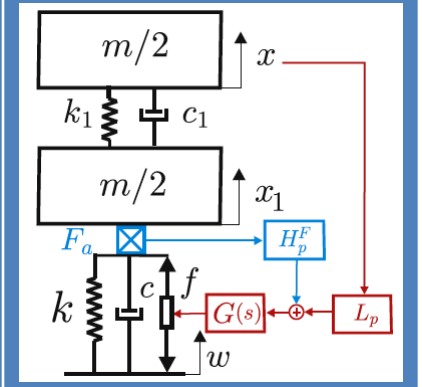
<u>Disadvantages:</u> difficult to collocate, flexible modes in the control bandwidth, phase lag…

System design and control bandwidth	=	Subtle compromise between sensor noise and sensor size

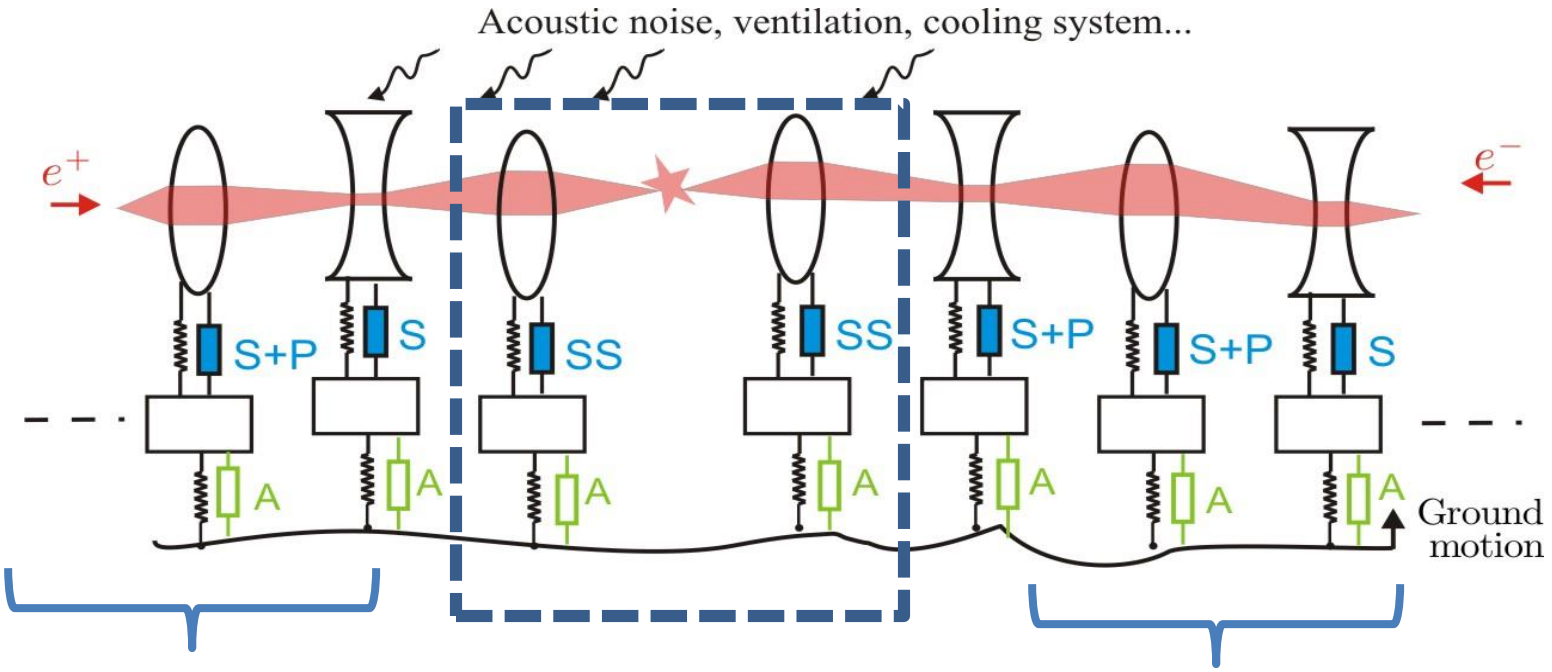
Sensor fusion



COLLETTE C. and MATICHARD F., Sensor fusion methods for high performance active vibration isolation systems, *Journal of sound and vibration*, 2015, vol.342, 1-21.

Inertial sensor merged with:	Accelero	Relative	Force
			

CLIC sketch



Main beam
2000 quadrupoles

1 nm >1 Hz

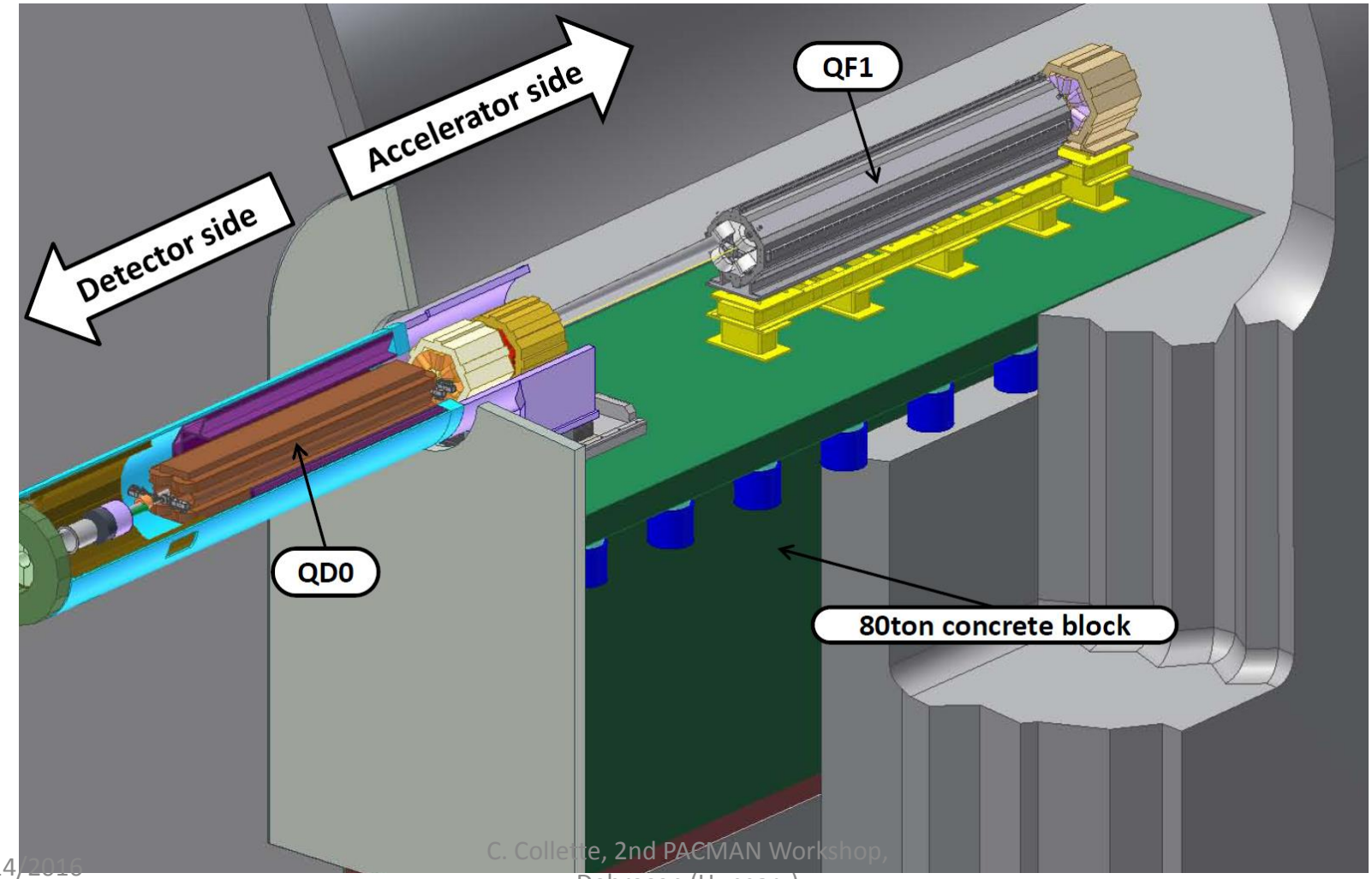
Final focus
4 quadrupoles

0.15 nm > 4 Hz

Main beam
2000 quadrupoles

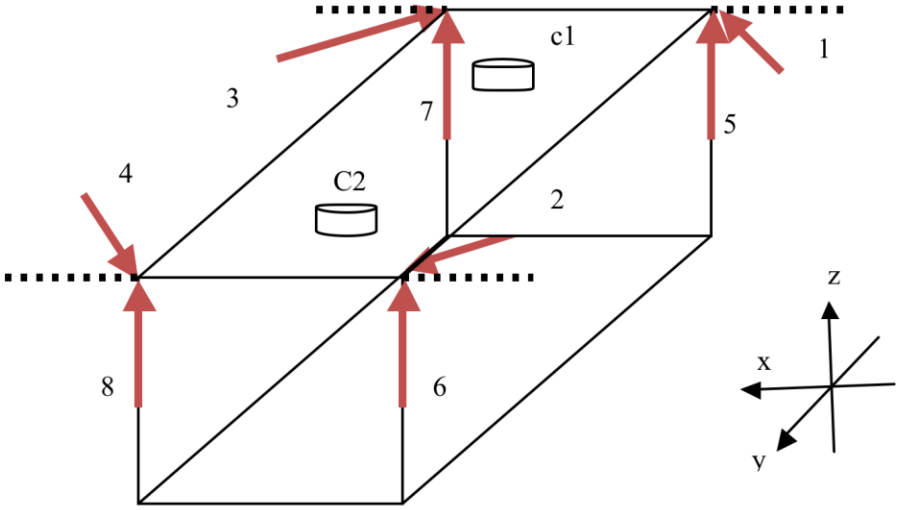
1 nm >1 Hz

CLIC final focus

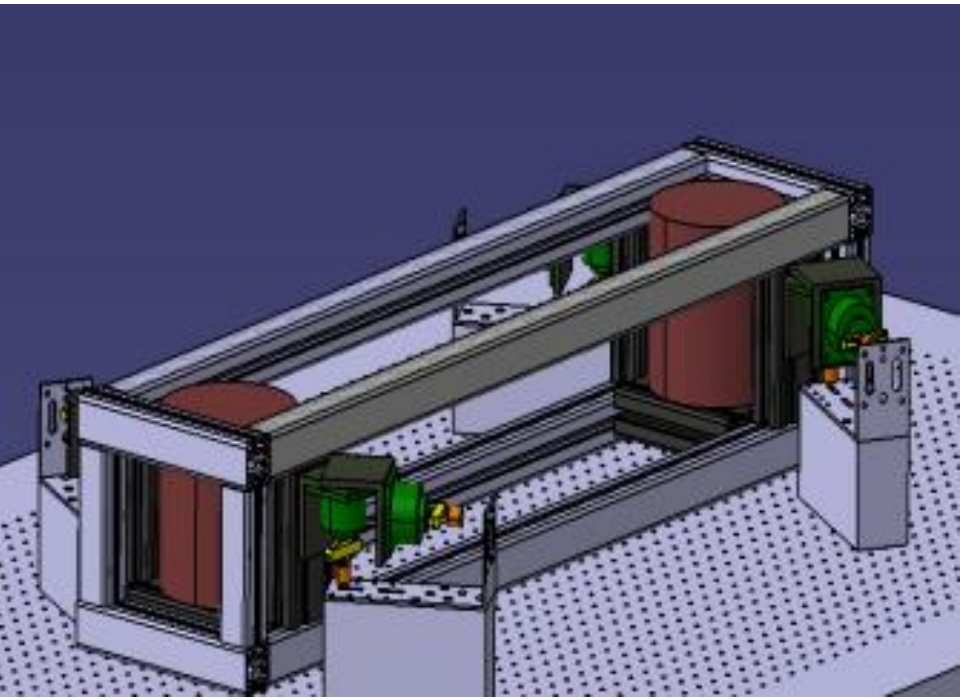


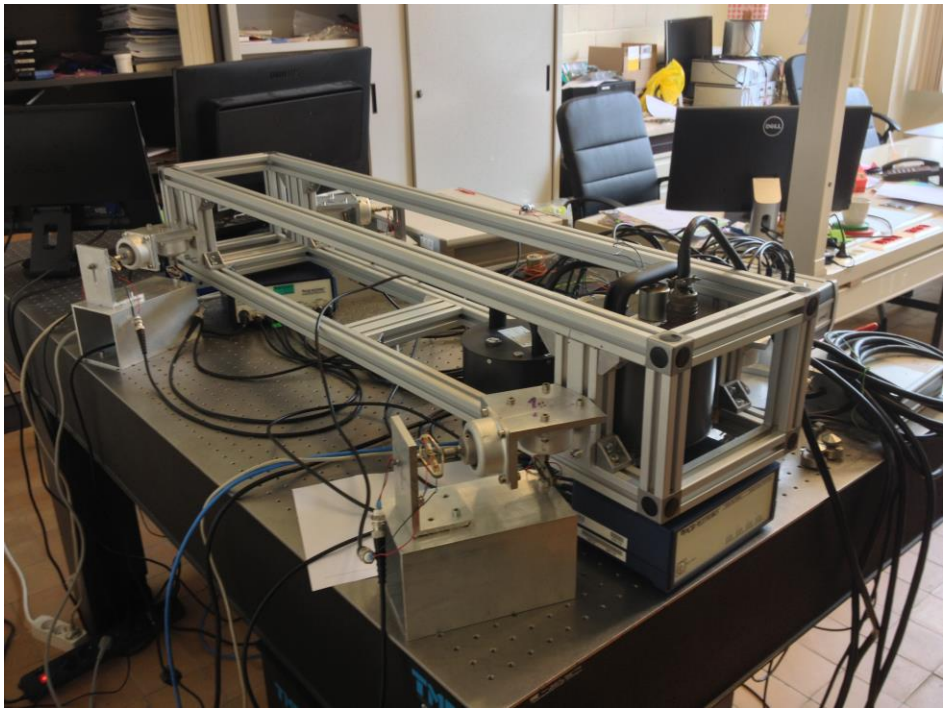
Supporting an extended object

- Rigid extended frame
- High authority along z
- Low authority along x
- Some stiffness along y
- Redundancy: 8 mounts
- Tunable vertical/horizontal decoupling



Test bench

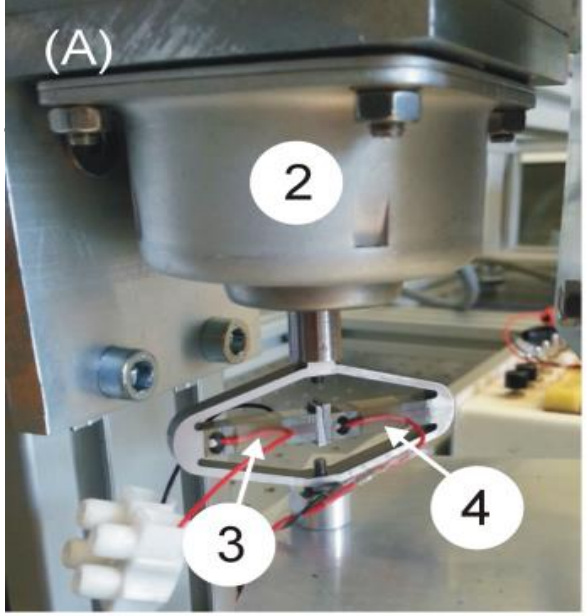




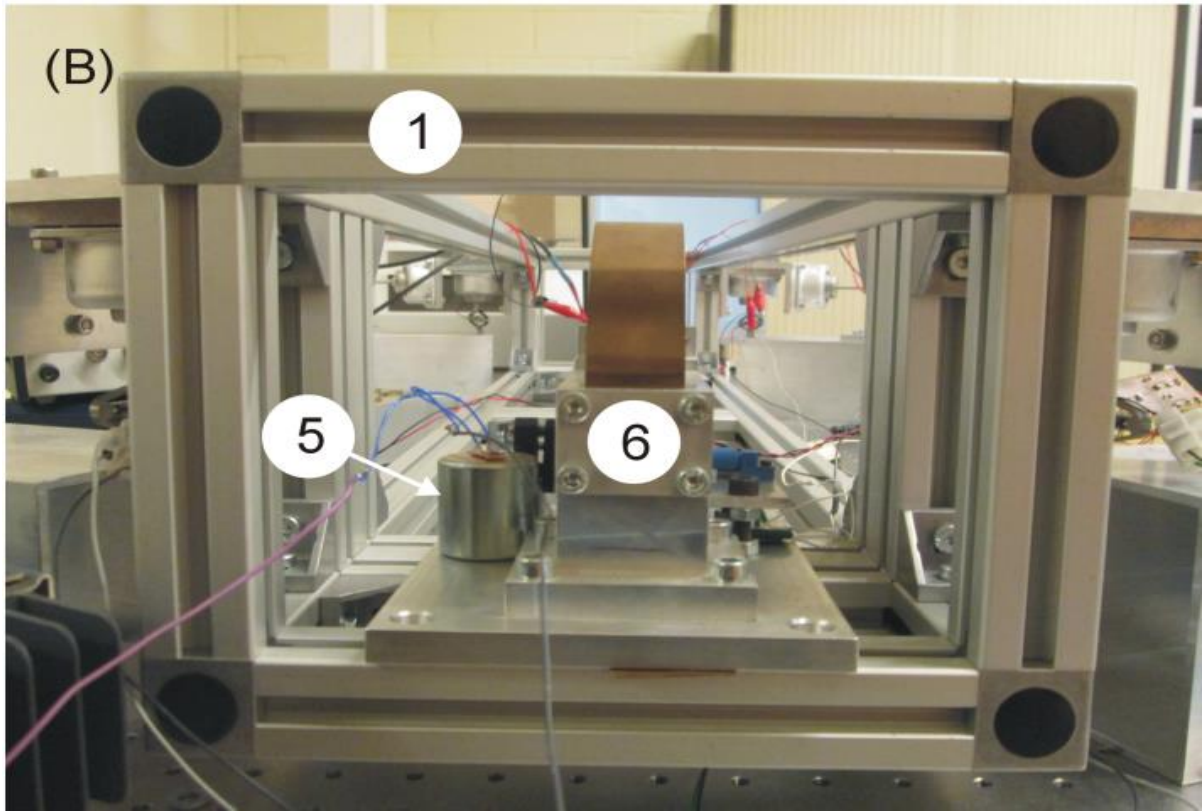
COLLETTE C., TSHILUMBA D., NASSIF F., FURNEMONT R., JANSSENS S., ARTOOS K., Vibration isolation of an extended object, Euspen's 15th conference, June 2015 (Leuven, Belgium).

(A) COIL-FREE ACTUATOR (piezoelectric in series with a metallic suspension).

(A) COIL-FREE SENSOR (optical inertial sensor used in the feedback loop).

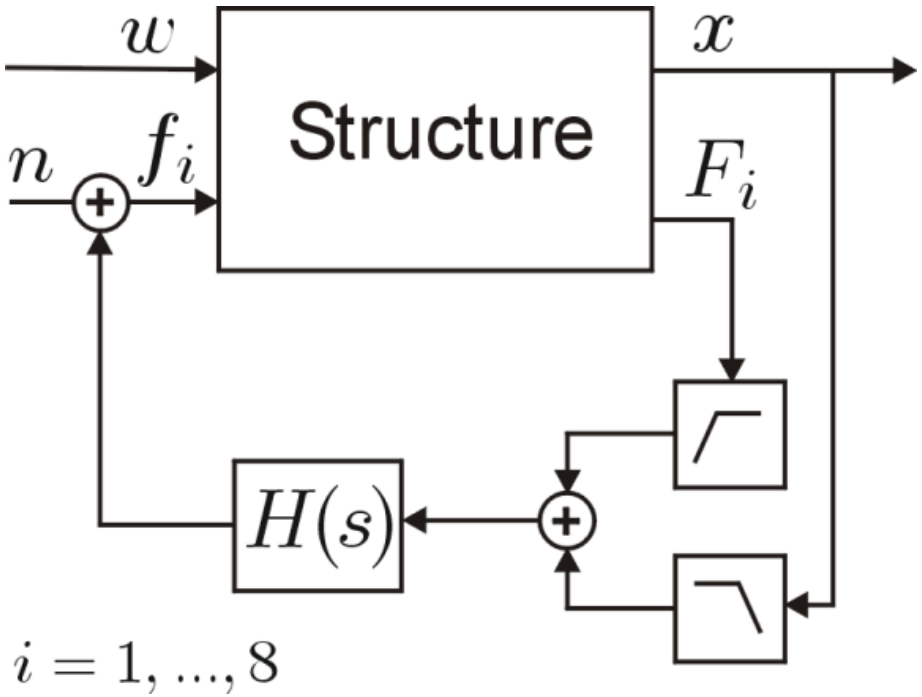


1. Extended frame
2. Metallic suspension Paulstra (7002-JA)
3. Piezoelectric stack actuator (APA-100M)
4. Piezoelectric force transducer (APA-100M)
5. Independant geophone (GS-11D)
6. Interferometric inertial sensor (NOSE)

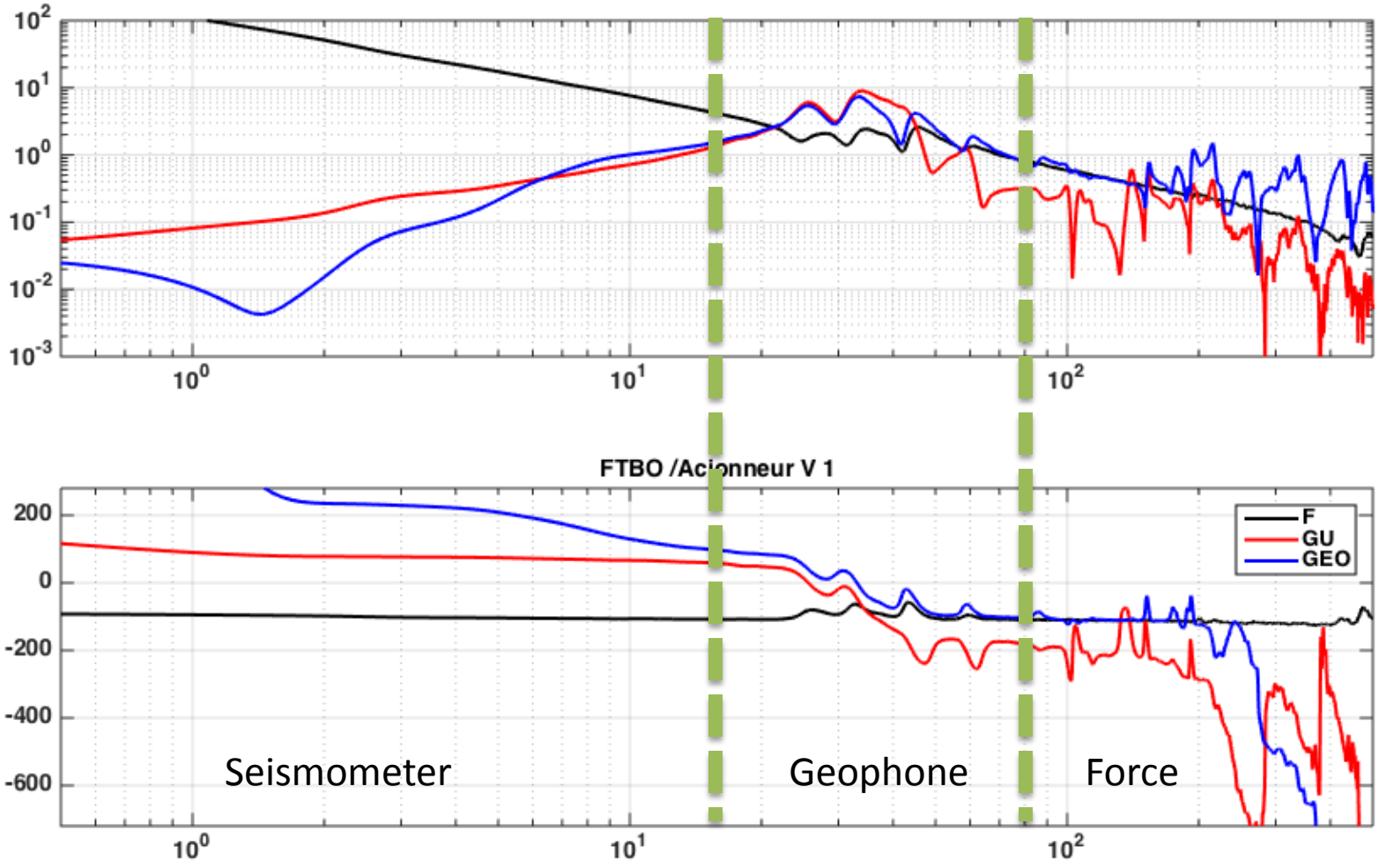


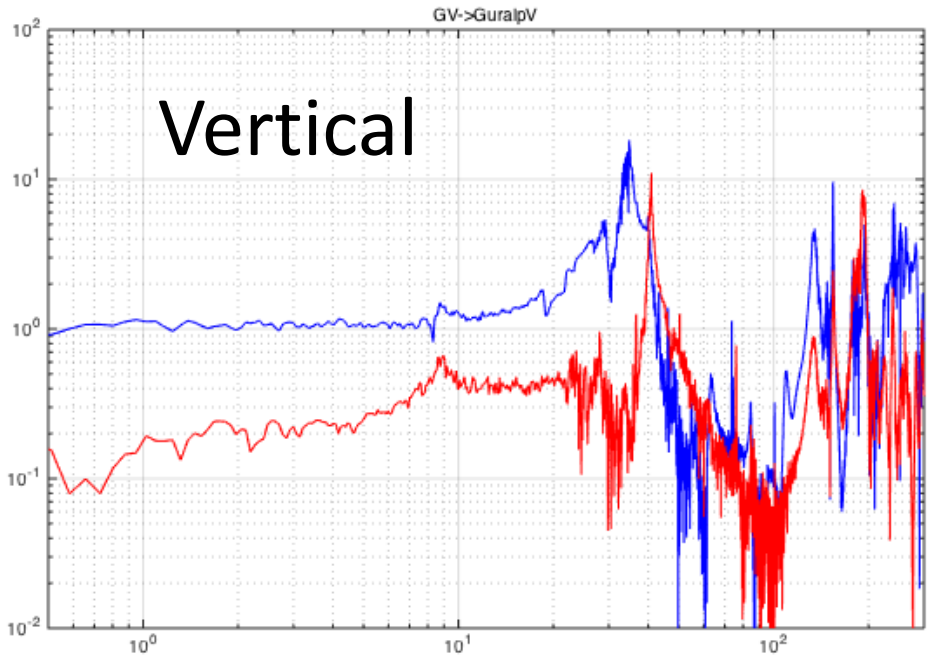
Active control strategy

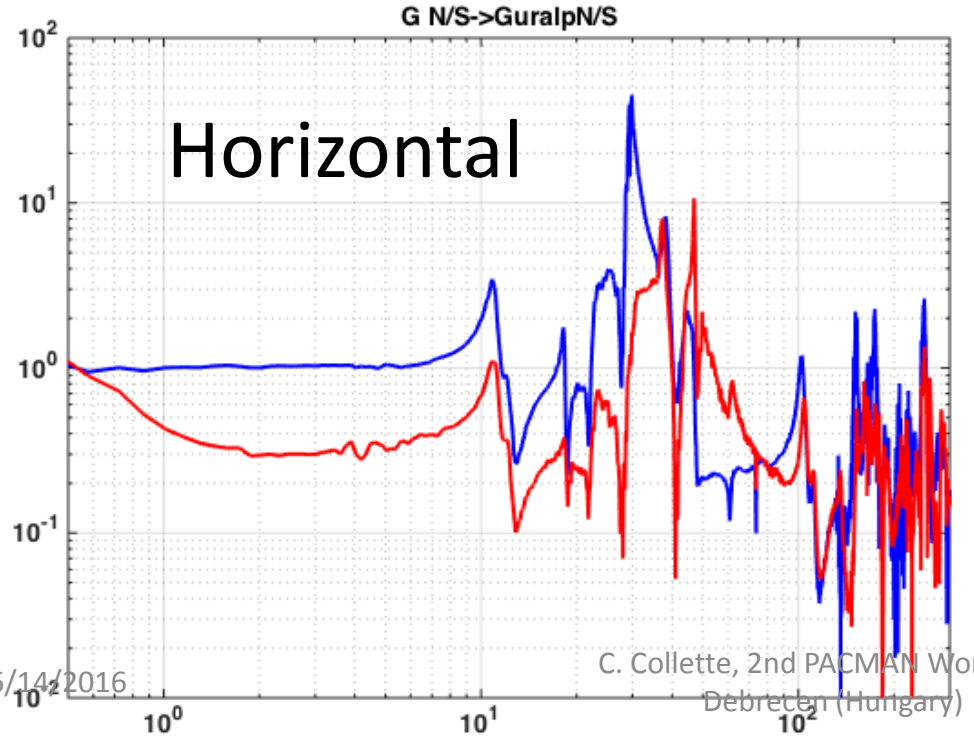
- Low frequency:
  - Centralized
  - Inertial control
- High frequency:
  - Decentralized
  - Force control



Open loop transfer function







Control OFF

Control ON

- 5/50 Reduction
- No spillover

Conclusions

- Support concept proposed
- Fusion of inertial sensor (LF) and force sensor (HF)
- Isolation in both vertical and lateral direction

Control does not rely on the knowledge of the plant

Future work

- Use the optical inertial sensor
- Improve voltage amplifier
- Improve decoupling of axes