European Organization for Nuclear Research

CLIC MAIN BEAM QUADRUPOLE STABILIZATION AT CERN

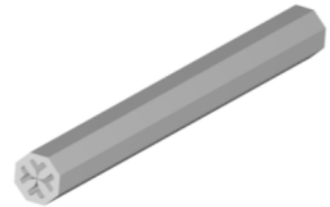
K. Artoos, P. Carmona-Fernandez, C. Collette, M. Guinchard, C. Hauviller, S. Janssens, A. Kuzmin, R. Leuxe, A. Slaathaug.

Outline

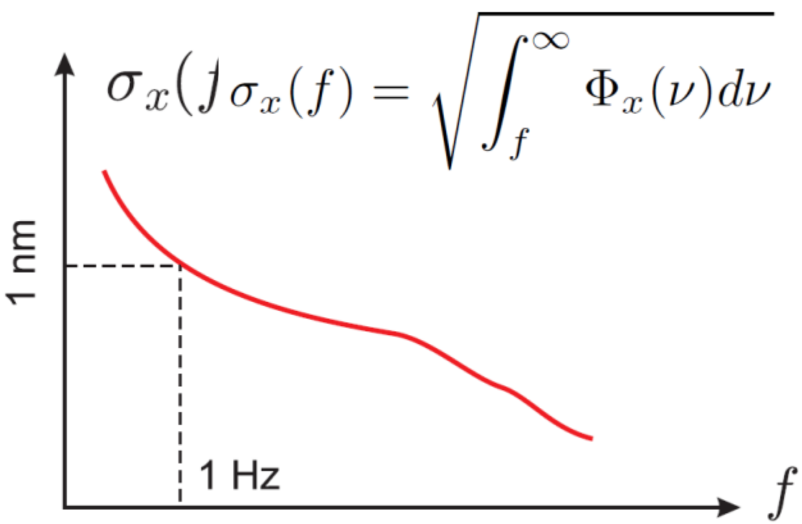
- Reminder requirements
- Four steps towards feasibility demonstration: achievements
- Propagation vibrations in floor
- Future work

Requirements

Quad. length: 0.5 to 2m
Quad. mass: ~ 100 to 400 Kg

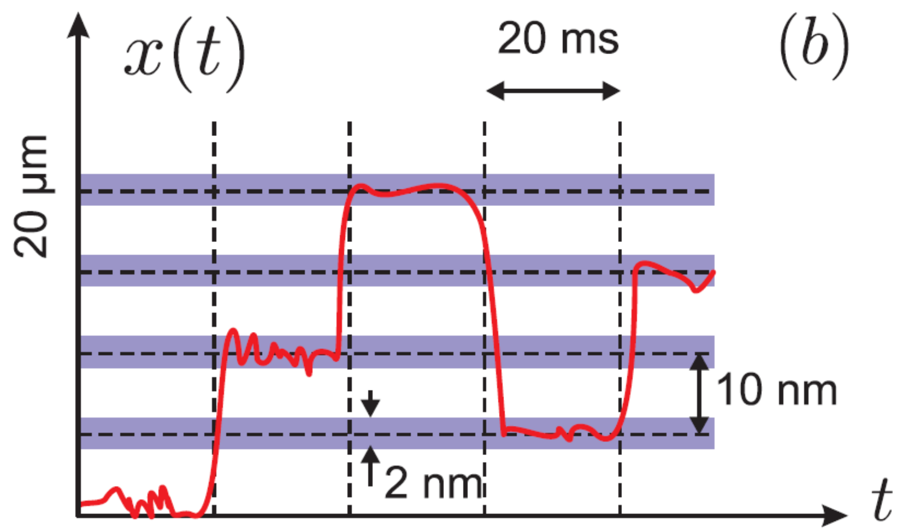


Stabilization



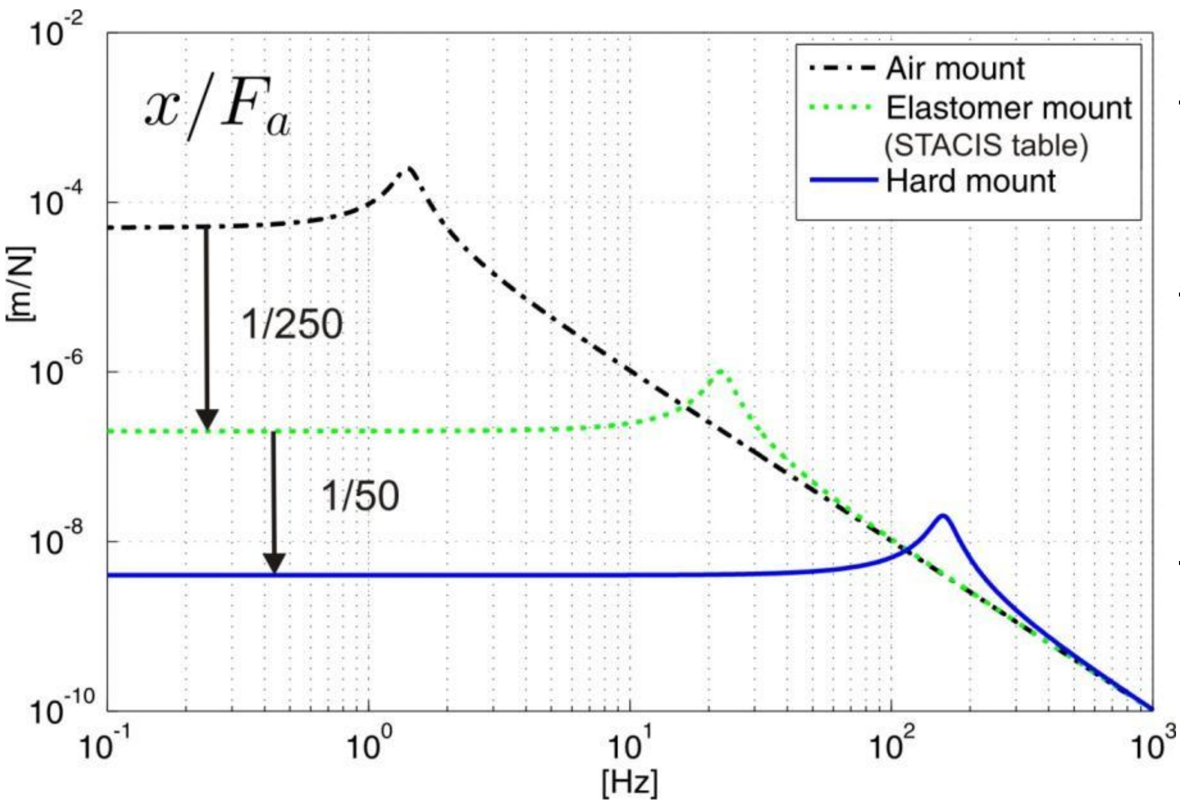
(5 nm in lateral direction)
2000 quadrupoles/line

Nano-positioning



(vertical and lateral)
80 quadrupoles/line

Other requirements



Available space

limited width and height

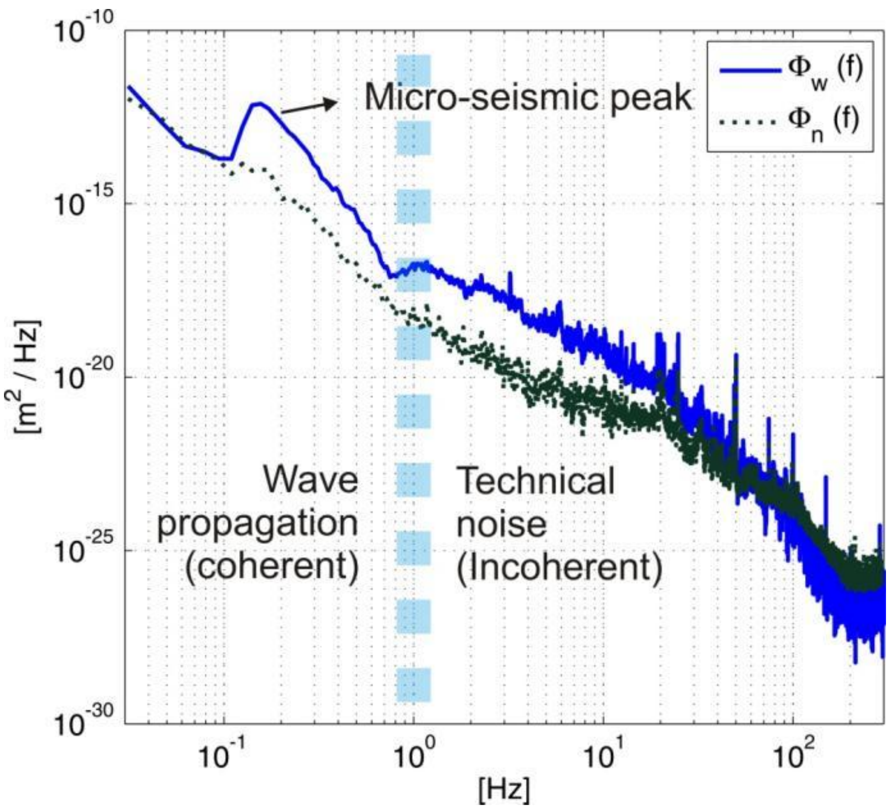
Accelerator environment

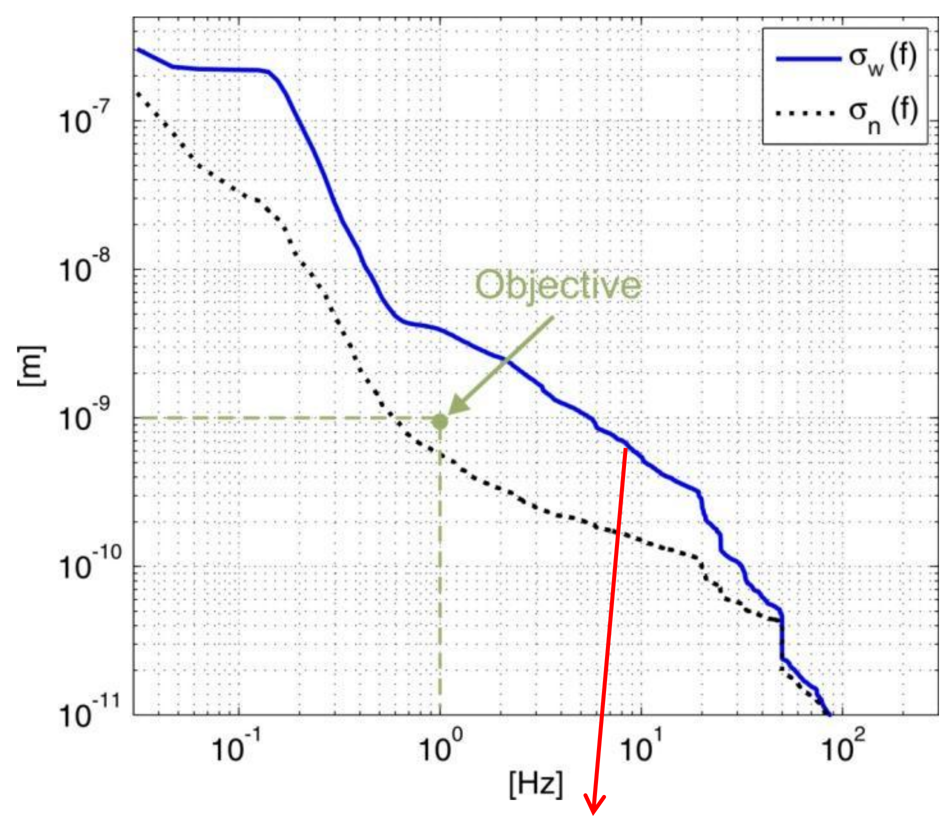
- High radiation (TDR)
- Stray magnetic field (TDR)

Robustness

- Uncertainty
- External forces : e.g. water cooling
- Alignment
- Transportable

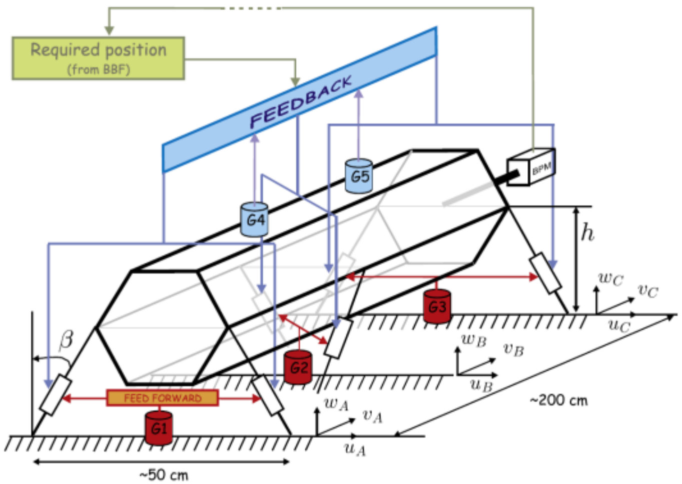
Typical ground motion





Main contribution below 20 Hz

Hexapod concept

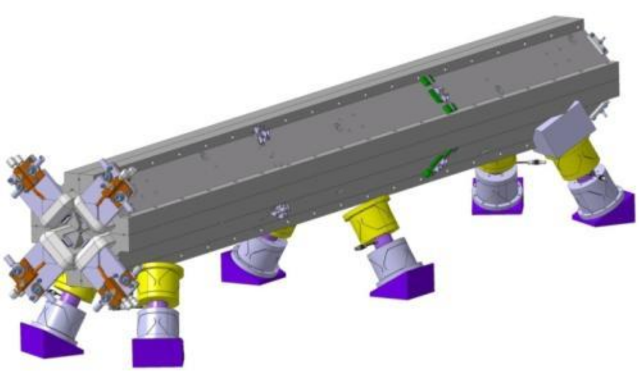


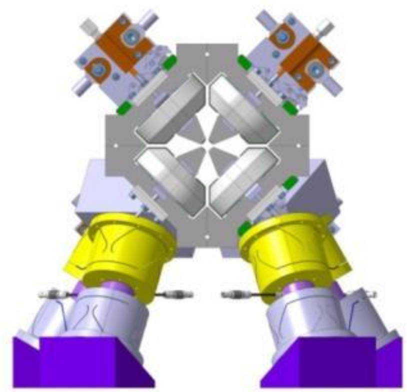
ILC-CLIC LET Beam Dynamics Workshop (23-25 June2009)

Advantages:

-Stabilization & Positioning in a single stage

- Robust to external forces





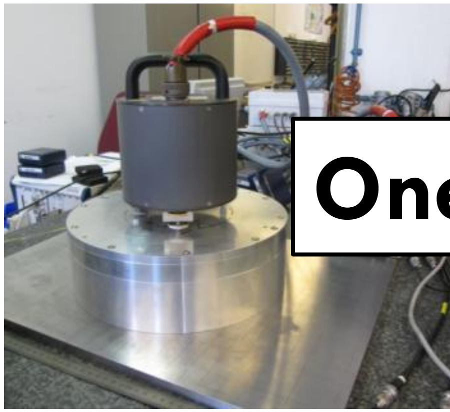
Disadvantages:

- Jointure issues
- Quadrupole flexibility

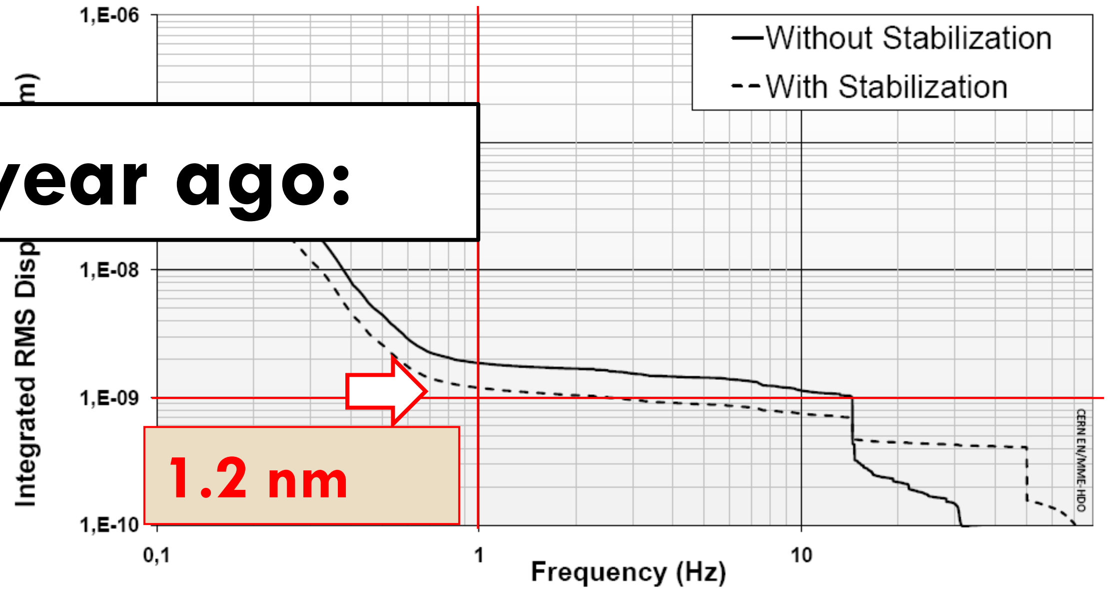
CERN option: steps towards hexapod

Findings from option CERN and LAVISTA

1. Stabilisation single d.o.f. with small weight (membrane)



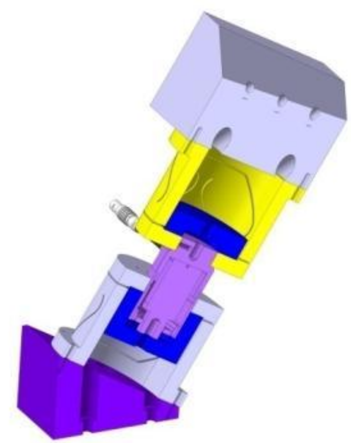
One year ago:



- First result:
- Program with further improvements

2. Tripod with weight type 1 MBQ with 1 active leg
   - Actuator and control amplifier ordered
   - Design legs, flexural hinges and dummy magnet ongoing
   - Control hardware available + control law being designed

   Target: first results this year



3. Tripod type 1 MBQ with 3 or 4 active legs
4. MOCK-UP Type 4 MBQ on hexapod

4 steps toward demonstration

2010 : 4 steps toward demonstration on MBQ type 4 (+ type 1):

- **1.** Stabilisation **1 d.o.f. with small mass** ("membrane")
- **2.** Stabilisation **1 d.o.f. with type 1 mass** ("tripod")
- **3.** Stabilisation **2 d.o.f. with type 1 mass** ("tripod")
- **4.** Stabilisation of **type 4 (and type 1)CLIC MB quadrupole proto type**

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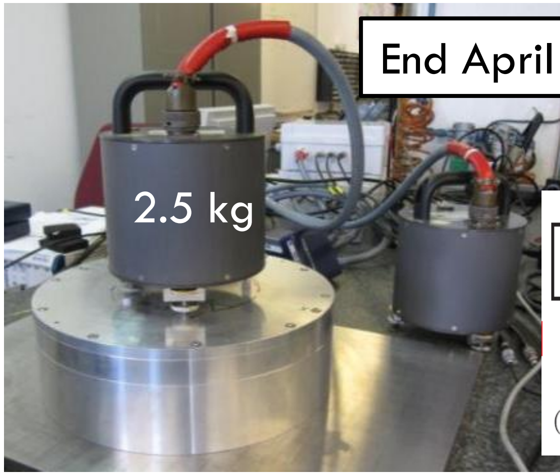
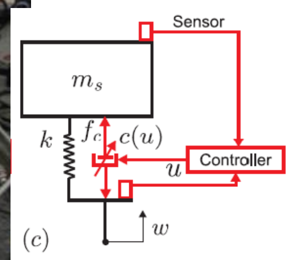
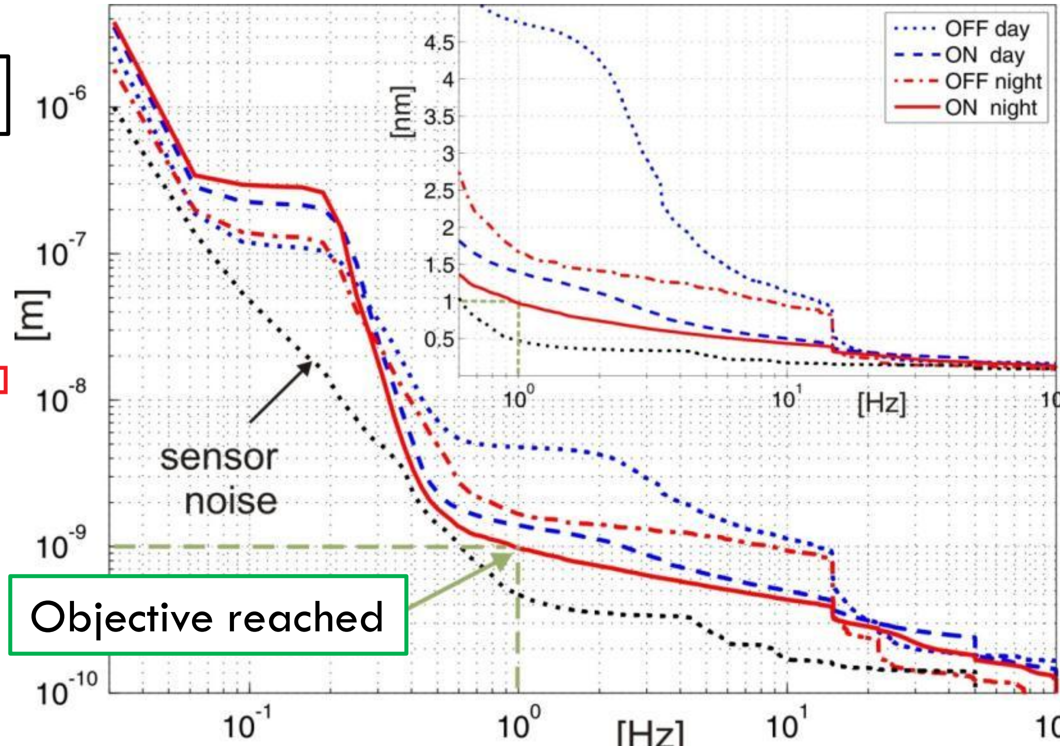
Steps toward performance demonstration RIGID option

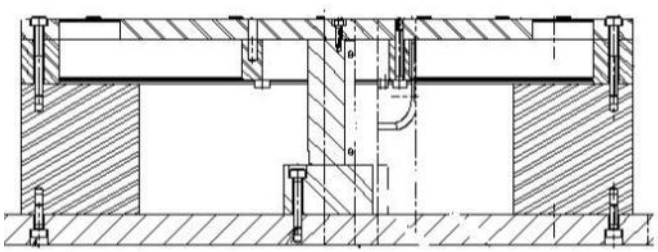
1. Stabilisation single d.o.f. with small mass ("membrane")

End April CERN 2010

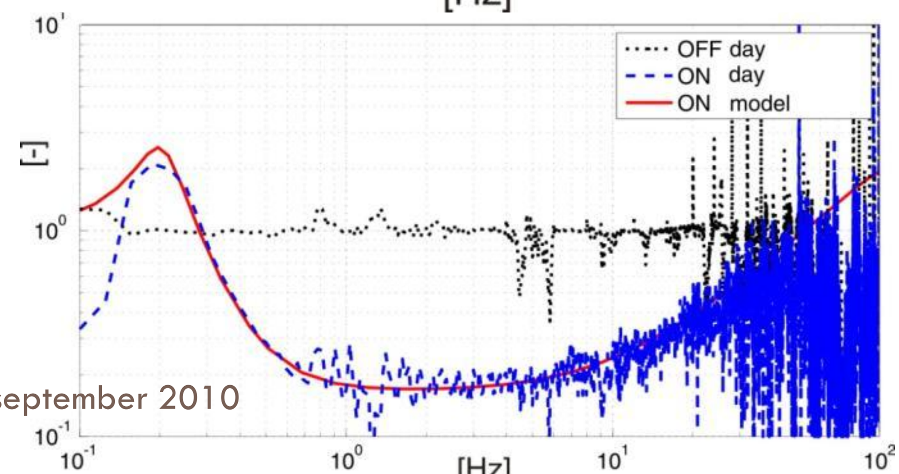








$$\frac{k}{m} = \frac{k'}{m'}$$



Piezo actuator (PI™): Resolution 0.1 nm

Stiffness 24 N/μm

Measured vertical resonant frequency ~ 300 Hz

Input from **<u>Pablo Fernandez Carmona</u>**:

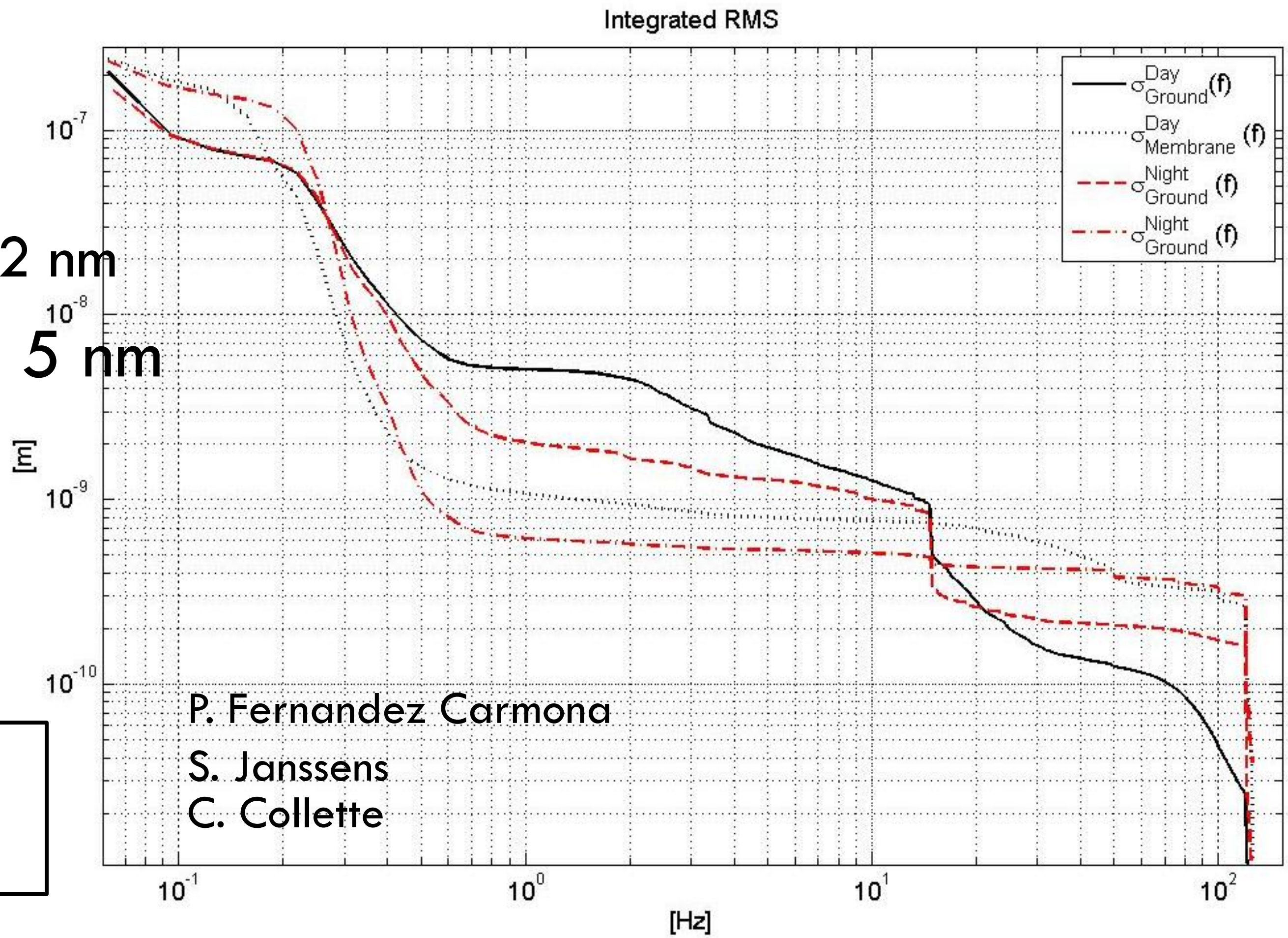
Systematic study and improvement of noise levels:

- Power supply seismometers
- Cabling to seismometer
- Noise level acquisition systems
- Noise level output

Best result on membrane:

<u>0.6 nm at 1 Hz</u> from 2 nm

1 nm at 1 Hz from 5 nm



P. Fernandez Carmona

S. Janssens

C. Collette

Test to be repeated and confirmed

4 steps toward demonstration

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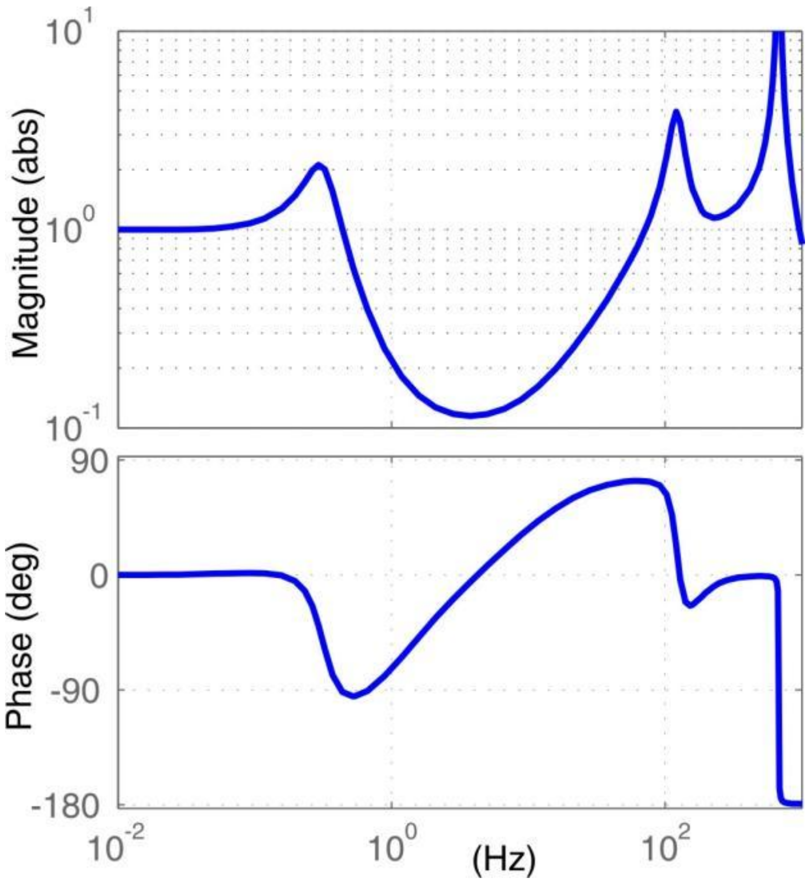
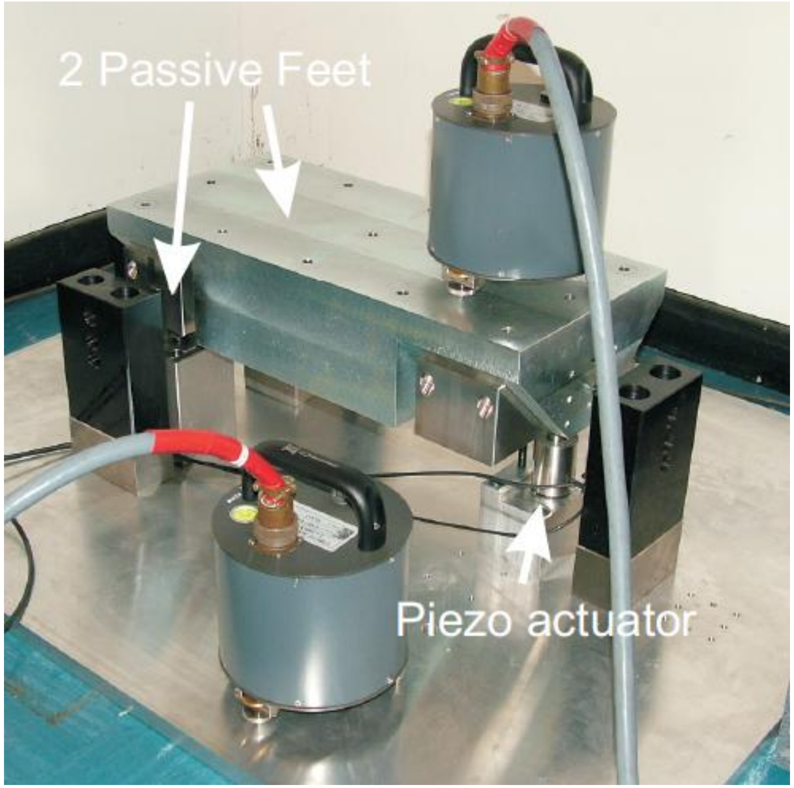
- 3. Stabilisation **2 d.o.f. with type 1 mass** ("tripod")
- 4. Stabilisation of **type 4 (and type 1)CLIC MB quadrupole proto type**

Step 2: One d.o.f. type 1 mass

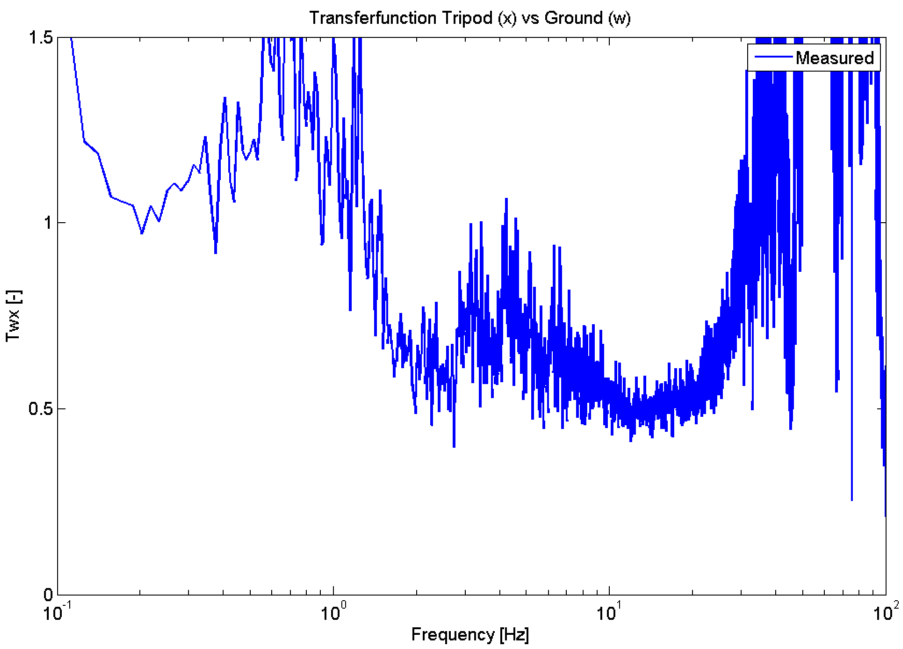
Objective: Validate the strategy with a heavy load + selected actuator



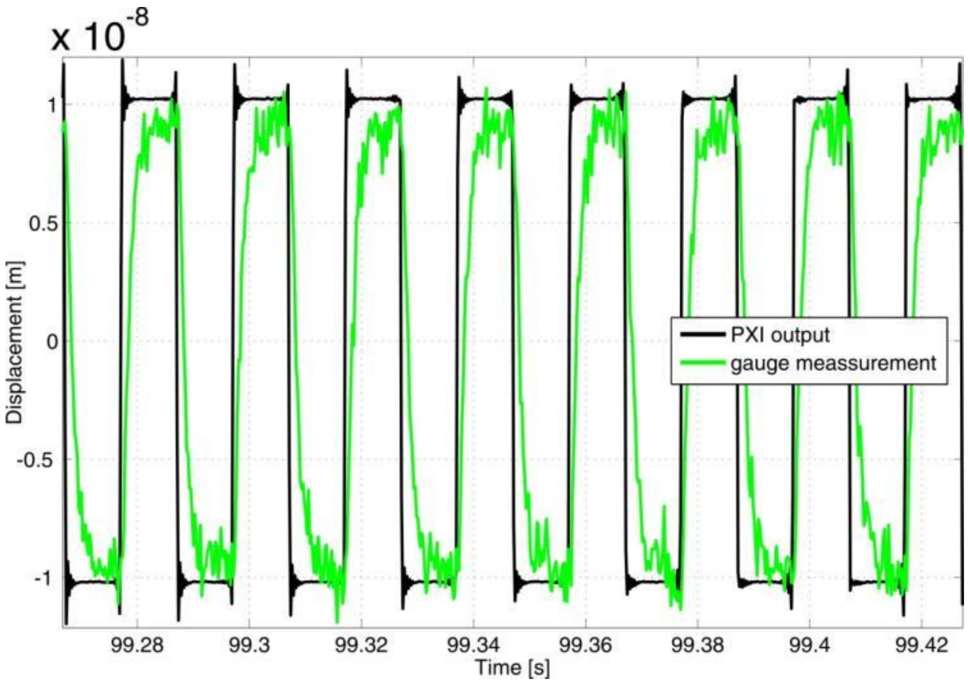


Step 2: One d.o.f. type 1 mass

Stabilisation



Nano-positioning:
square wave of 20nm @ 100 Hz



Support to be improved, no guidance

4 steps toward demonstration

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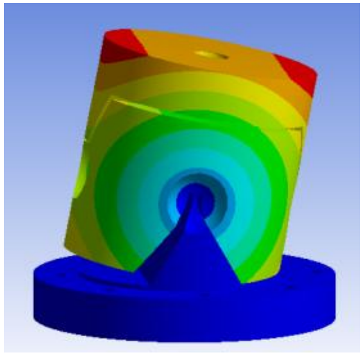
Step 3: 2 d.o.f. with type 1 mass

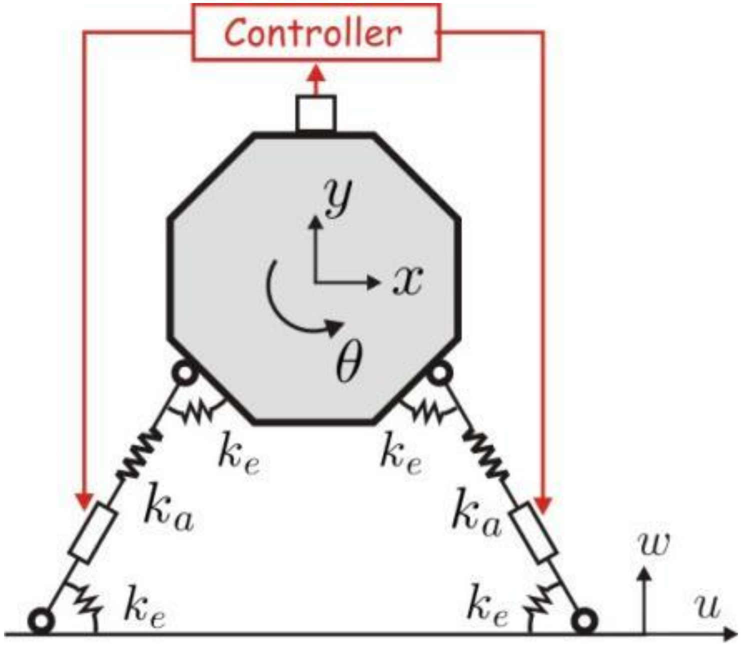
DECISION: Block longitudinal → Actuator pairs in same plane

Block Roll → X- Y guidance

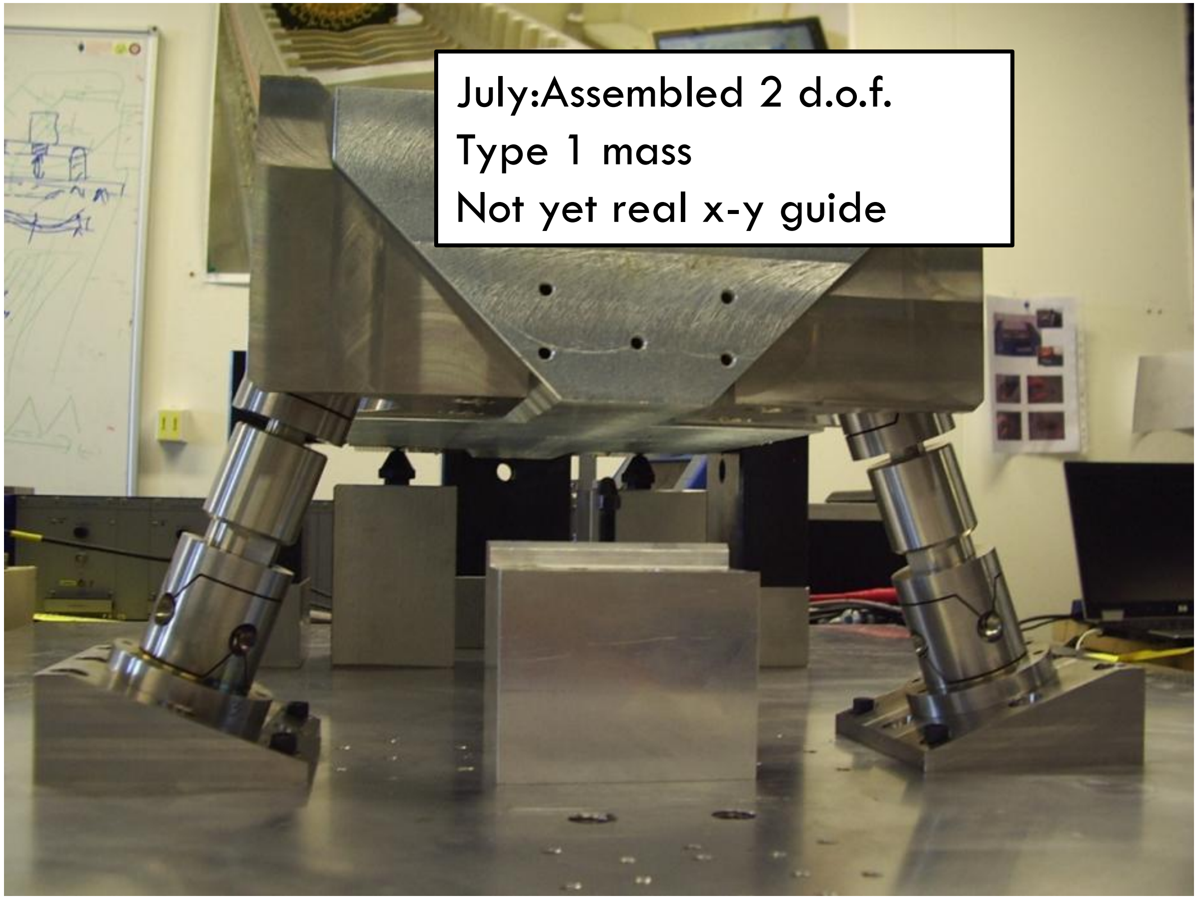


Objectives:

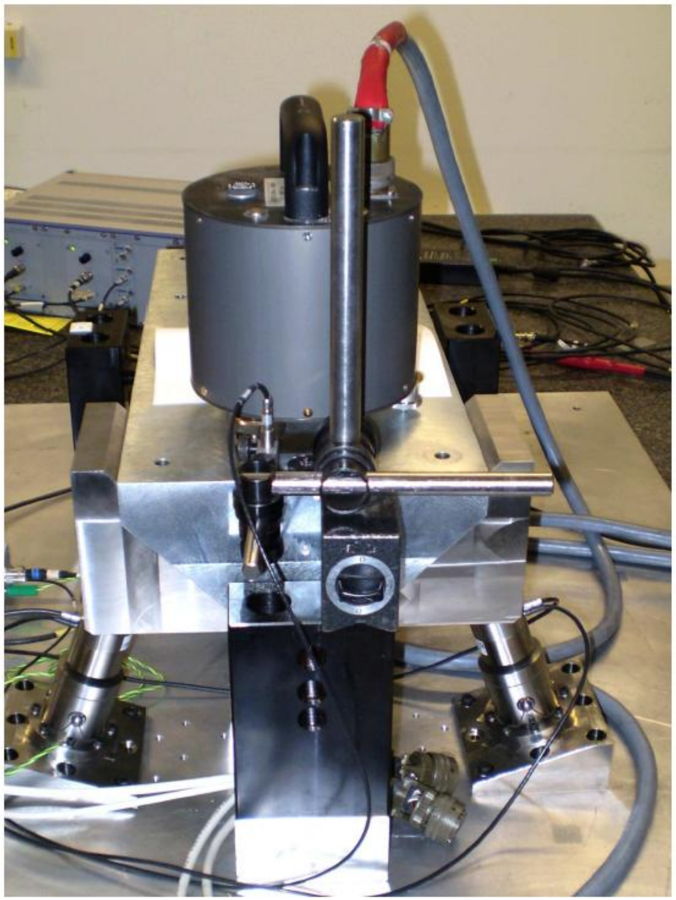
- Validate the strategy in two d.o.f.
- Joint design
- Mounting and assembly issues (Stiff structure = stresses on Piezo)

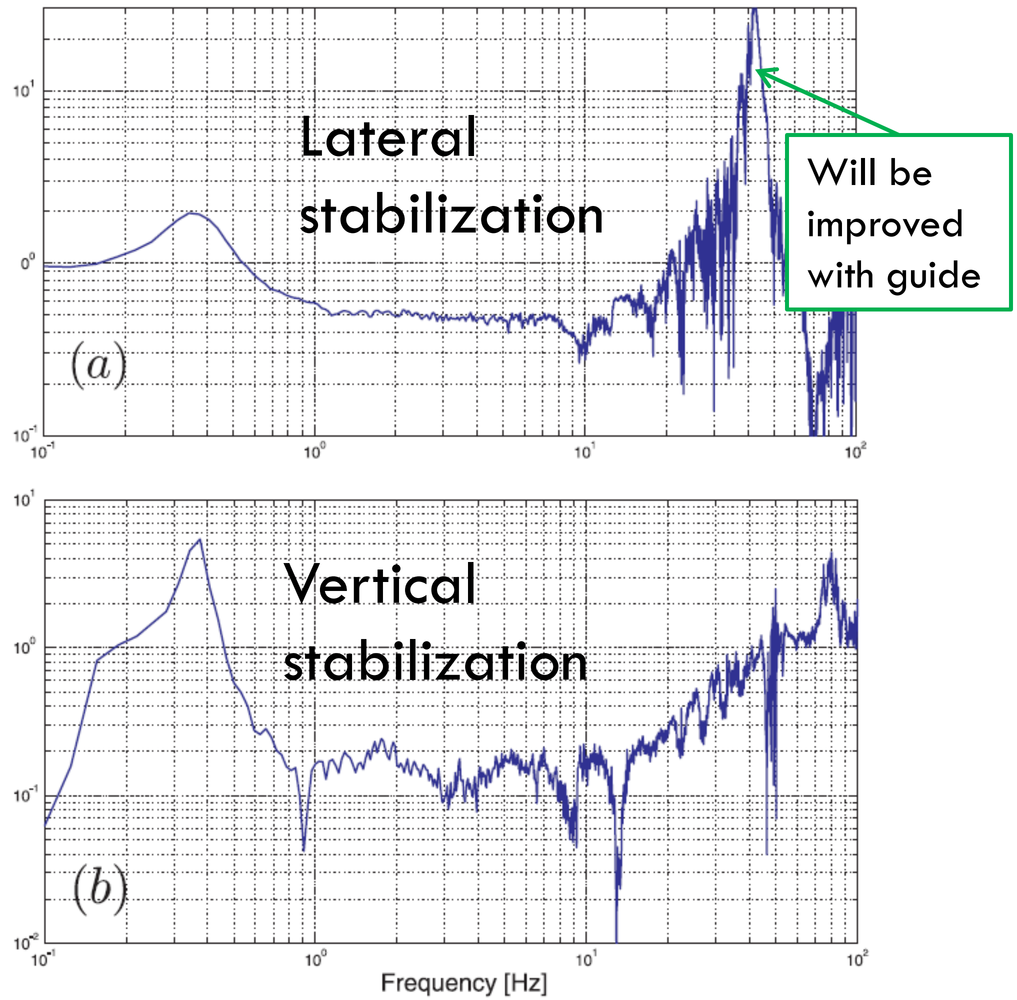


Stabilization in 2 d.o.f.

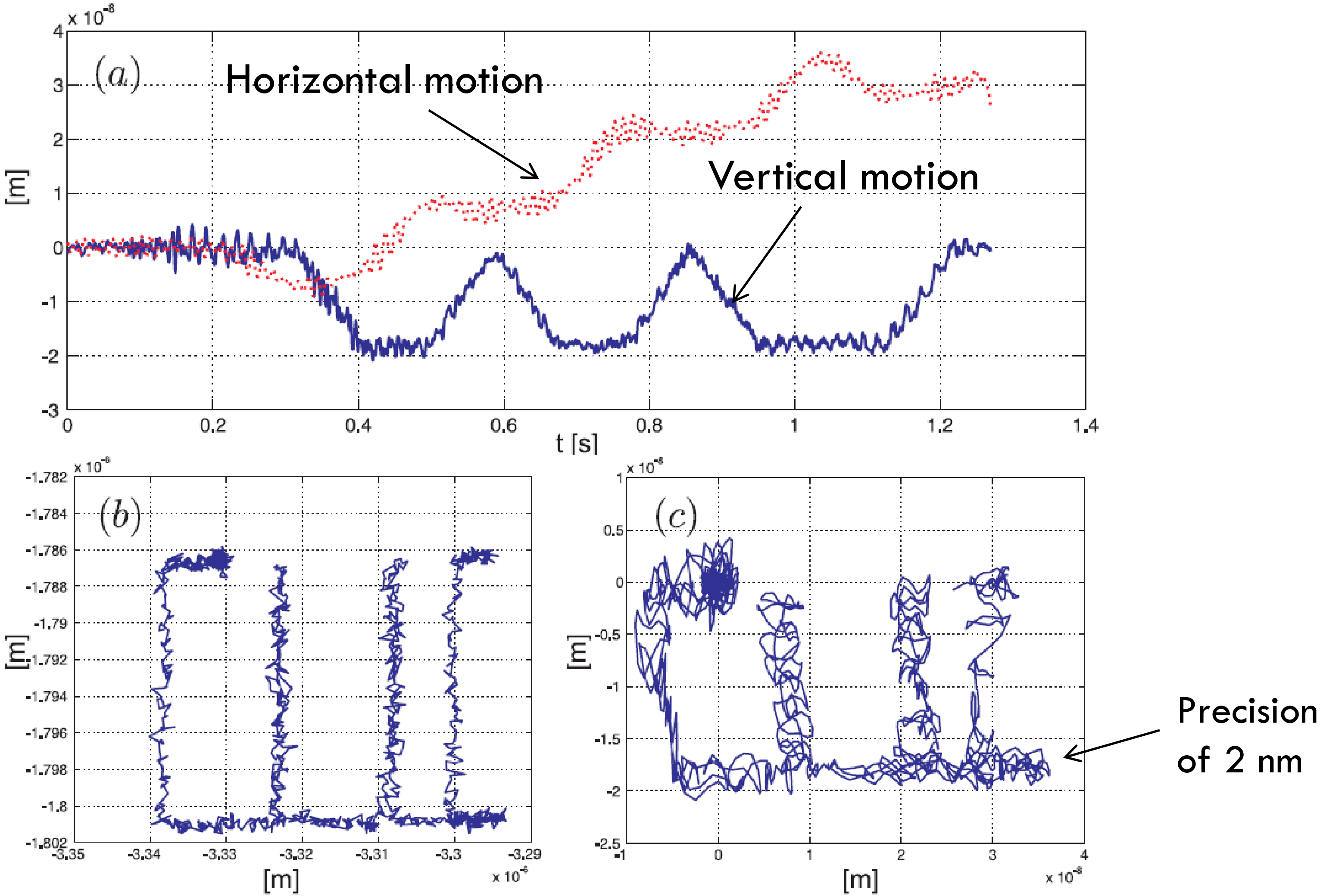


Simultaneous stabilisation in 2 d.o.f.





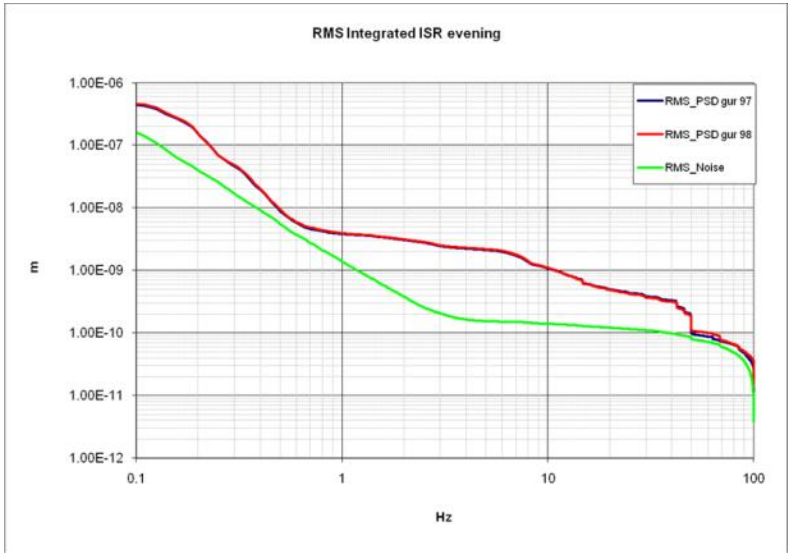
Positioning in 2 d.o.f.



To do:

- Demonstrate stabilisation and nano positioning with low vibration back ground.
- New place proposed by M. Modena and M. Buzzio in ISR with water cooling! Measurements ongoing

Remark: ISR could be a great place for the test module lab .....



A. Slaathaug

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Design x-y guide: status

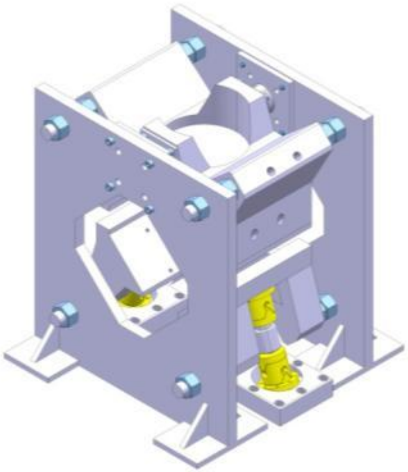
Concept:

hyperguided table with 8 flexural beams

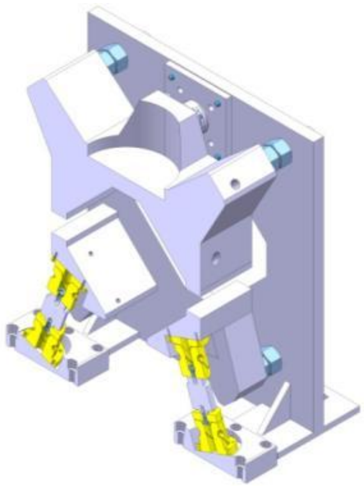
Bellows to block roll

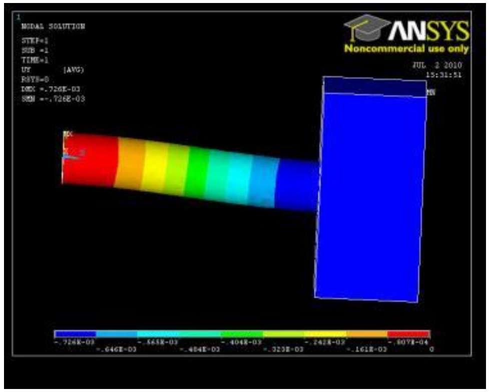
Objective:

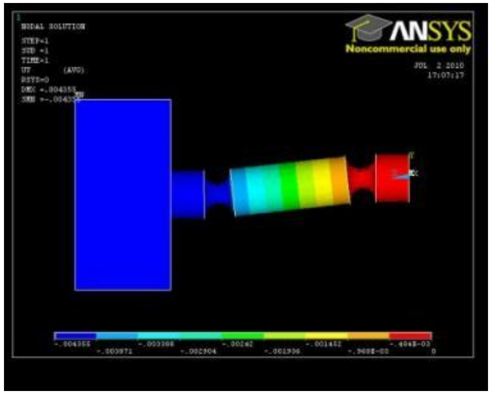
Designing for a low x-y rigidity and high longitudinal and roll rigidity

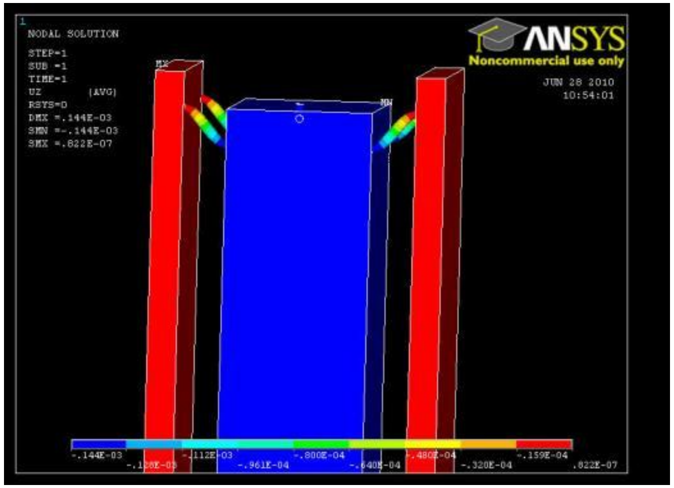


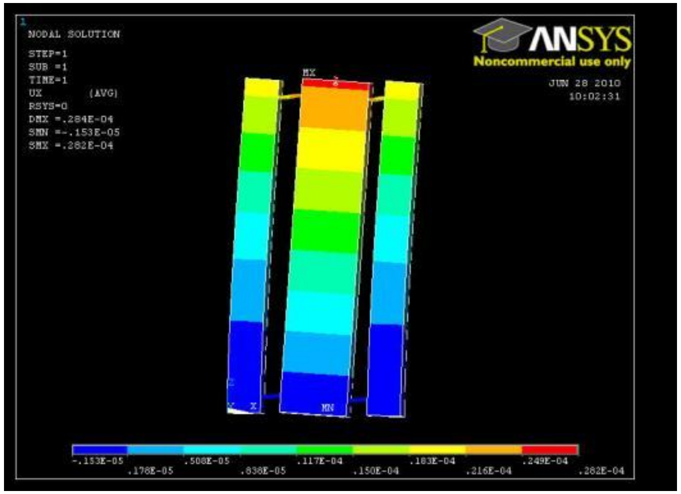
Type 1



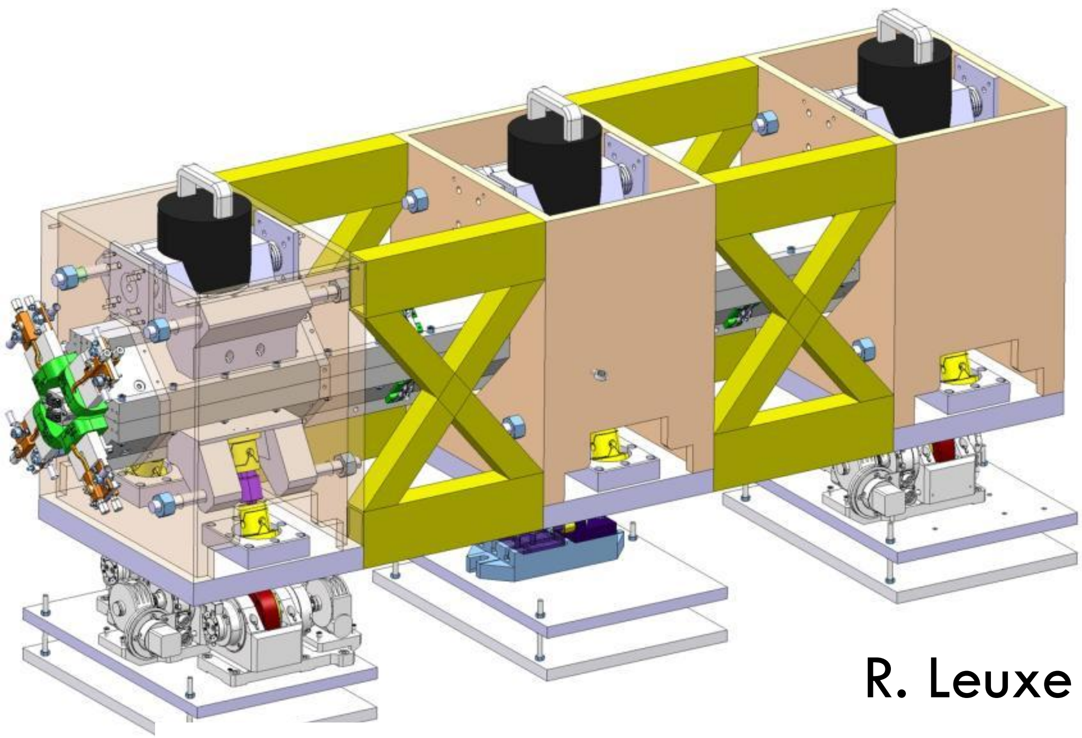




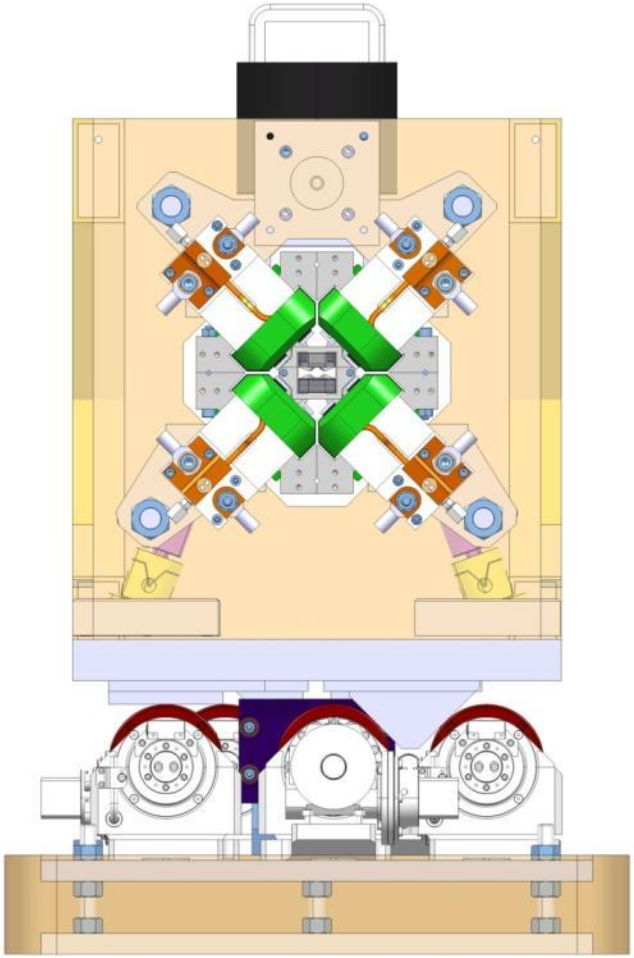




Concept drawing



R. Leuxe



Alignment stage:
Courtesy H. Mainaud Durand

Functions x-y guide:

• **Add a direct measurement of the x-y displacement** with respect to intermediate platform

To replace instrumentation in legs

Has a zero position (reference mark on grating) for fiducialisation

Sensitivity and noise level does not change with position (unlike capacitive gauges)

Less strict alignment requirements sensor

Could become low cost for large serie

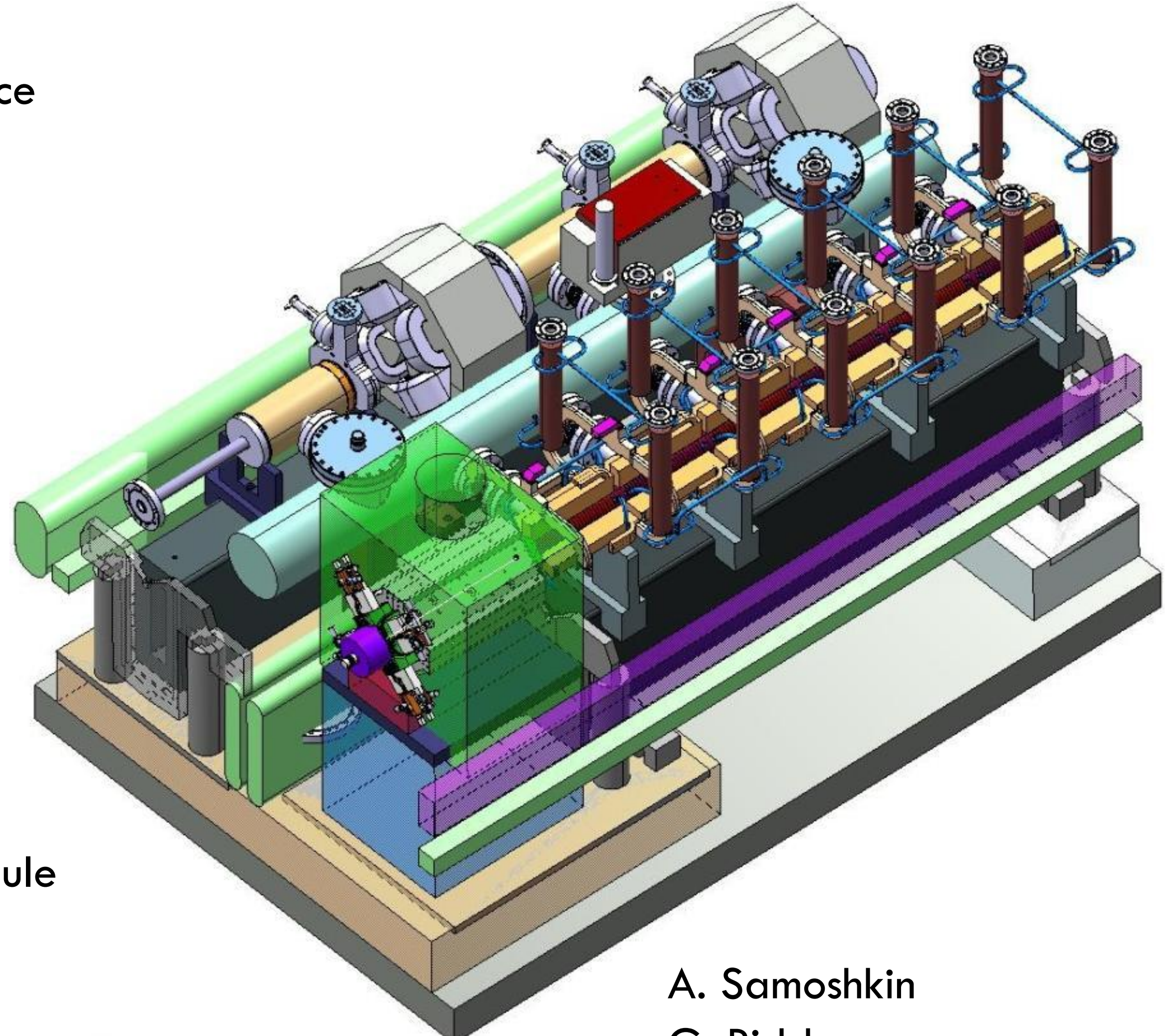
LIP 281 Linear encoder 1 nm/TTL

• Introduce the possibility to **protect piezo actuators during transport**

• Could make it possible to reduce the number of actuators.

• The x-y guides can be built together to form a girder around the magnet as the intermediate platform between alignment and stabilisation

Compatible with available space



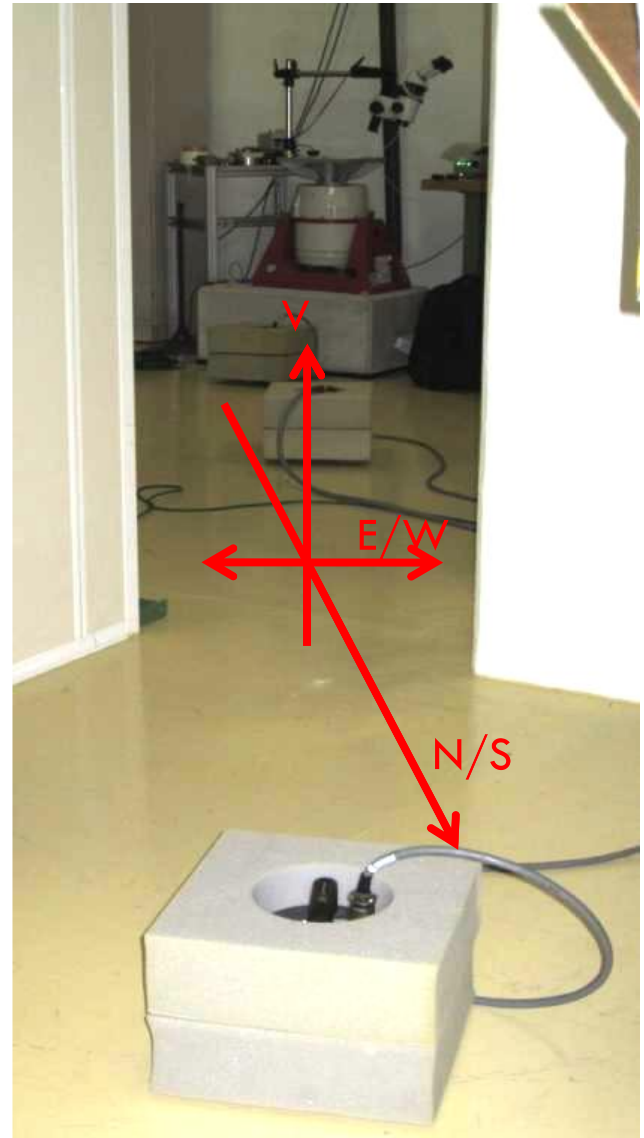
Integration in two beam module

A. Samoshkin
G. Riddone

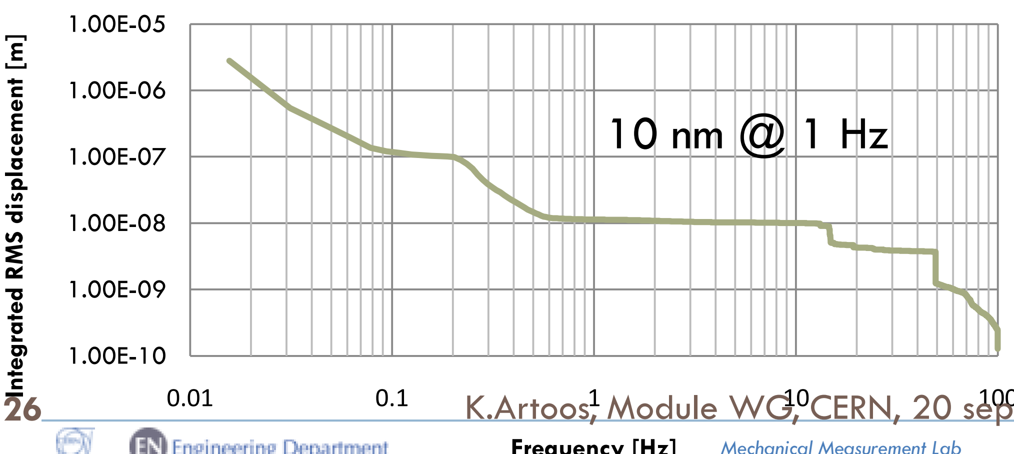
To do: Integrate the concept drawing exactly in type 4 and type 1 module

Setup: ground vibration transmission test

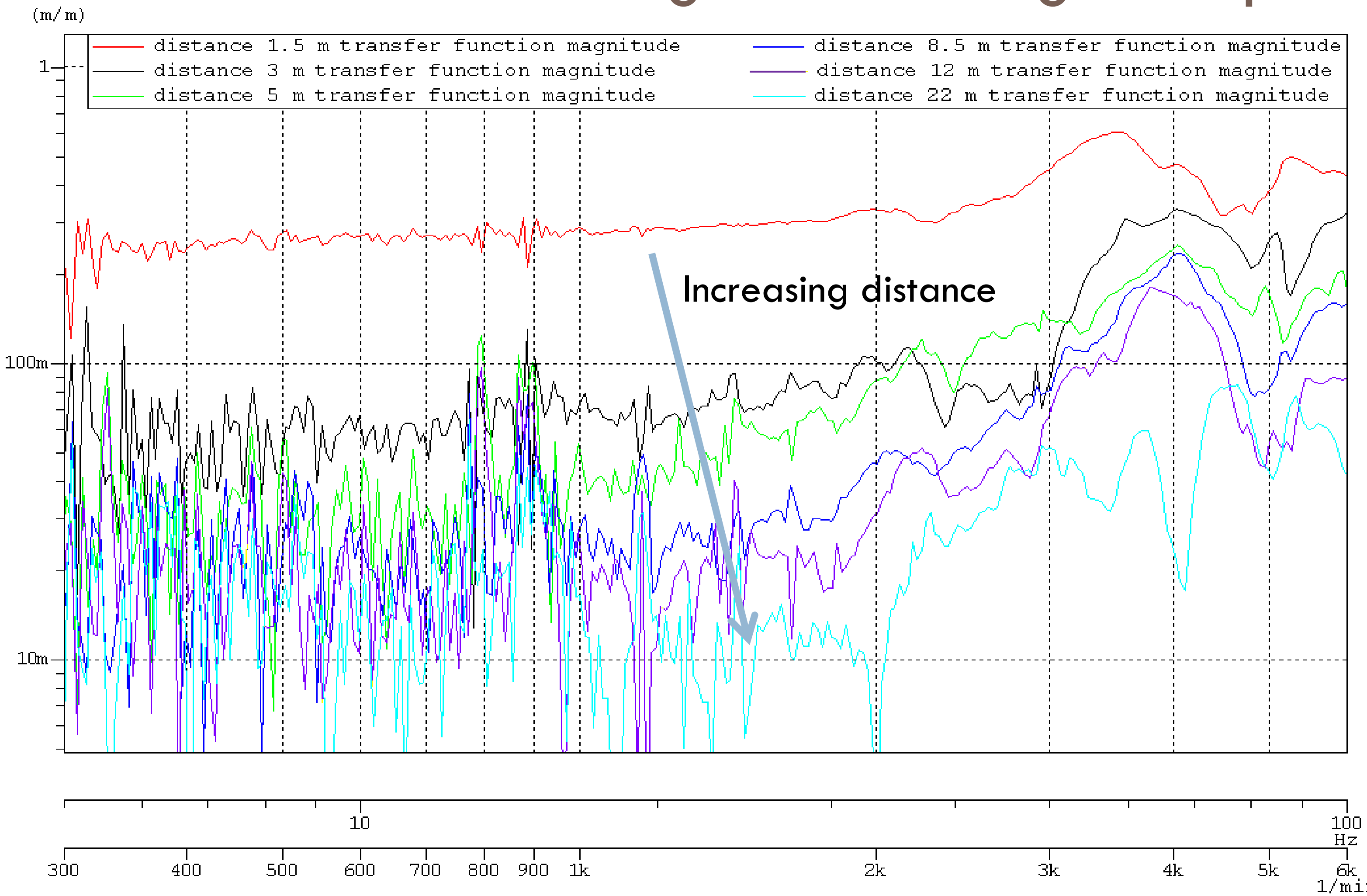
Michael Guinchard & Ansten Slaathaug



Integrated RMS Bldg 186 without excitation



Transfer function magnitude along sweep sine.



– Transfer function magnitude between reference geophone and geophone at measured points

Conclusions & Future work

- Steps 1 to 3: concepts validated, to be finalised with low back ground
- Future work:
  - Design : T4 + T1 Guide + girder, optimisation weight + stiffness
  - Improvement of control strategy
  - Work on sensor performances and noise reduction
  - Compatibility with the rest of the machine: BBF (ΔT ?)
  - Vibration sources (propagation) characterisation
  - T1 and T4: Modal analysis + Tests with water cooling

Publications last 6 months (1/2)

- COLLETTE C., ARTOOS K., KUZMIN A., SYLTE M., GUINCHARD M. and HAUVILLER C., Active quadrupole stabilization for future linear particle colliders, *Nuclear instruments and methods in physics research section A*, vol.621 (1-3) pp.71-78 (2010).
- COLLETTE C., ARTOOS K., GUINCHARD M. and HAUVILLER C., Seismic response of linear accelerators, *Physical reviews special topics – accelerators and beams* vol.13 pp. 072801 (2010).
- ARTOOS K., COLLETTE C., GUINCHARD M., JANSSENS S., KUZMIN A. and HAUVILLER C., Compatibility and integration of a CLIC quadrupole nano-stabilization and positioning system in a large accelerator environment, *IEEE International Particle Accelerator Conference IPAC10*, 23-25 May 2010 (Kyoto, Japan).
- ARTOOS K., COLLETTE C., GUINCHARD M., JANSSENS S., LACKNER F. and HAUVILLER C., Stabilisation and fine positioning to the nanometer level of the CLIC Main beam quadrupoles, *IEEE International Particle Accelerator Conference IPAC10*, 23-25 May 2010 (Kyoto, Japan).
- COLLETTE C., ARTOOS K., JANSSENS S. and HAUVILLER C., Hard mounts for quadrupole nano-positioning in a linear collider, *12th International Conference on New Actuators ACTUATOR2010*, 14-16 May 2010 (Bremen, Germany).

Publications last 6 months (2/2)

- COLLETTE C., JANSSENS S., ARTOOS K. and HAUVILLER C., Active vibration isolation of high precision machine (keynote lecture), *6th International Conference on Mechanical Engineering Design of Synchrotron Radiation Equipment and Instrumentation (MEDSI 2010)*, 14 July 2010 (Oxford, United Kingdom).
- COLLETTE C., JANSSENS S., ARTOOS K., GUINCHARD M. and HAUVILLER C., CLIC quadrupole stabilization and nano-positioning, *International Conference on Noise and Vibration Engineering (ISMA2010)*, 20-22 September 2010 (Leuven, Belgique).
- JANSSENS S., COLLETTE C., ARTOOS K., GUINCHARD M. and HAUVILLER C., A sensitiviy analysis for the stabilization of the CLIC main beam quadrupoles, *Conference on Uncertainty in Structural Dynamics*, 20-22 September 2010 (Leuven, Belgique).
- FERNANDEZ-CARMONA P., COLLETTE C., JANSSENS S., ARTOOS K., GUINCHARD M., KUZMIN A., SLAATHAUG A., HAUVILLER C., Study of the electronics architecture for the mechanical stabilization of the quadrupoles of the CLIC linear accelerator, Topical Workshop on Electronics for Particle Physics TWEPP 2010, 20-24 September 2010 (Aachen, Germany).