Laboratoire d'Annecy-le-Vieux
de Physique des Particules

MSTBT
Metrology and stabilisation

A.Jeremie

B.Bolzon, L.Brunetti, N.Geffroy

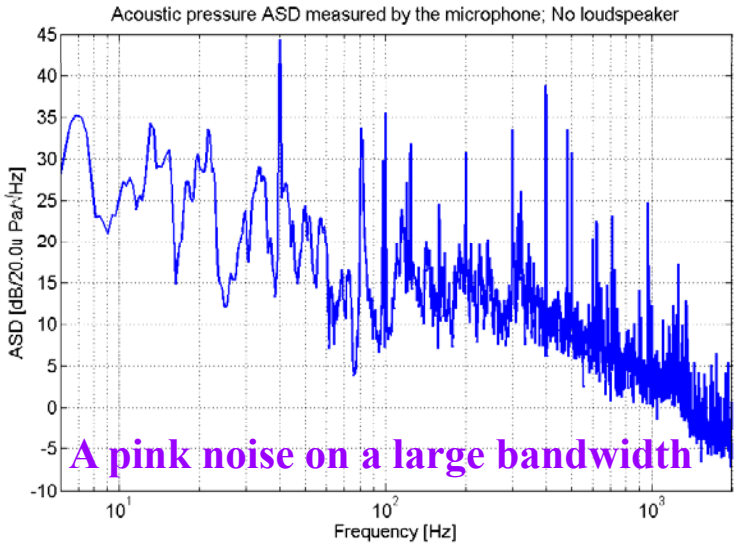
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

IN2P3
INSTITUT NATIONAL DE PHYSIQUE NUCLÉAIRE ET DE PHYSIQUE DES PARTICULES

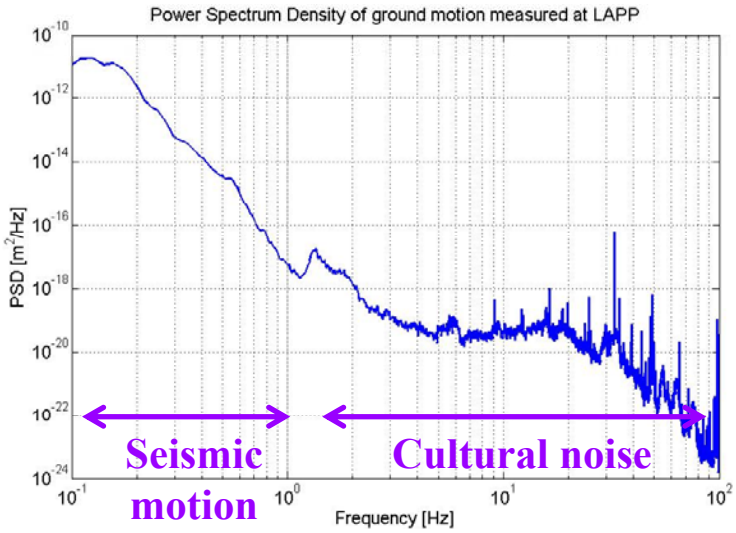
UNIVERSITE CHAMBERY ANNECY SAVOIE

Example of spectral analysis of different disturbance sources

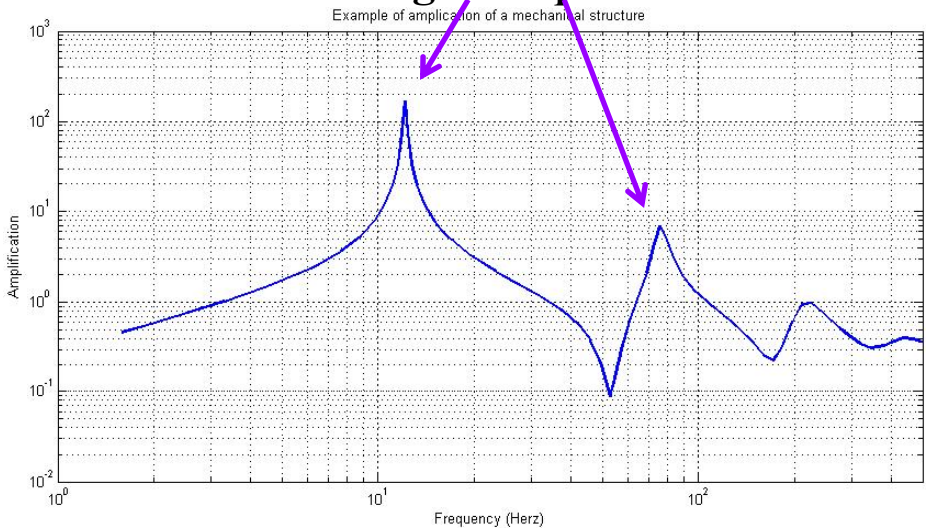
✓ Acoustic disturbance :



✓ Ground motion :



✓ Amplified by the structure itself : the eigenfrequencies

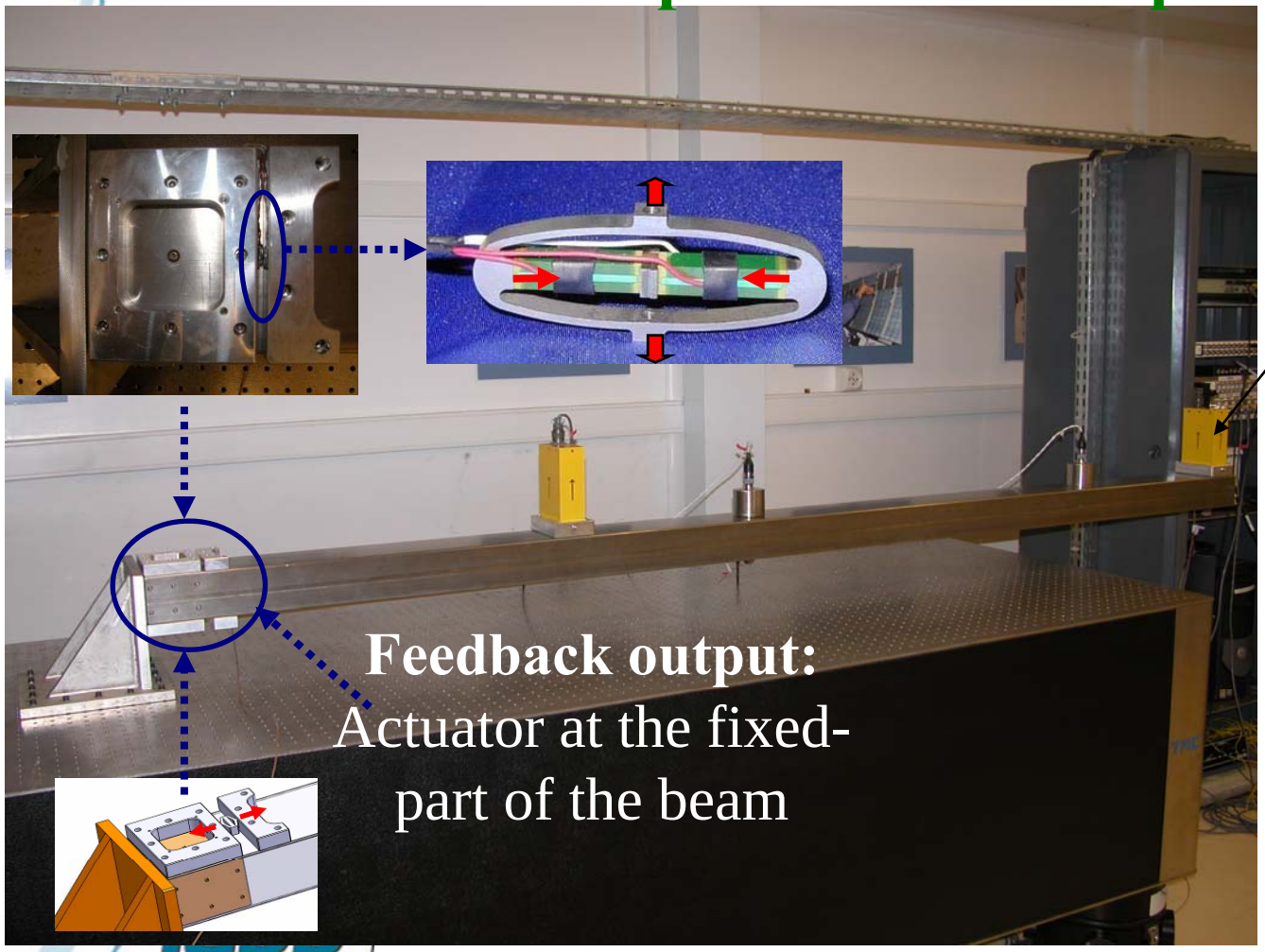


=>need to isolate and compensate

First results of stabilisation in the nanometre scale

This mock-up and feedback are the “end deliverable” for our task

Experimental set-up



Feedback output:
Actuator at the fixed-part of the beam

Feedback input:
Sensor at the free-part of the beam

PCI6052 DAQ:
Sensor acquisition and actuator control

State of the art inertial sensors

✓ **NI PCI-6052 Multifunction DAQ**

PCI-6052E	Quantity	Resolution	Rate	Conversion	Range	Noise
Analog Input	8 Differential/ 16 Single-ended	16bits	Up to 333kS/s	Successive approximation	±0.05 to 10V	60uV from DC to 1MHz
Analog output	2 Single-ended	16 bits	333kS/s	Successive approximation	±10V	

Fast card **Low noise card**

➢ Compatible Matlab/Simulink (Softwares used for the algorithm)

Sensors	**SP500B**	**ENDEVCO86**
Sensitivity	2000V/m/s	10V/g
Frequency range	0.0167 – 75Hz	0.01 – 100 Hz
Integrated electronic noise above 4Hz	0.085nm	0.6nm
Quantity	2	2

Sensors	VE-13	Guralp CMG-40T	SP400U	GSV-320	ENDEVCO 86
Sensitivity	1V→1 mm/s	1V→0.625mm/s	1V→1 mm/s	1V→0.5 mm/s	1V→0.1g
Garanteed frequency range	1 - 315 Hz	0,033 - 50 Hz	0,1-50 Hz	1 - 315 Hz	1-100 Hz
Quantity	2	2	2	2	2

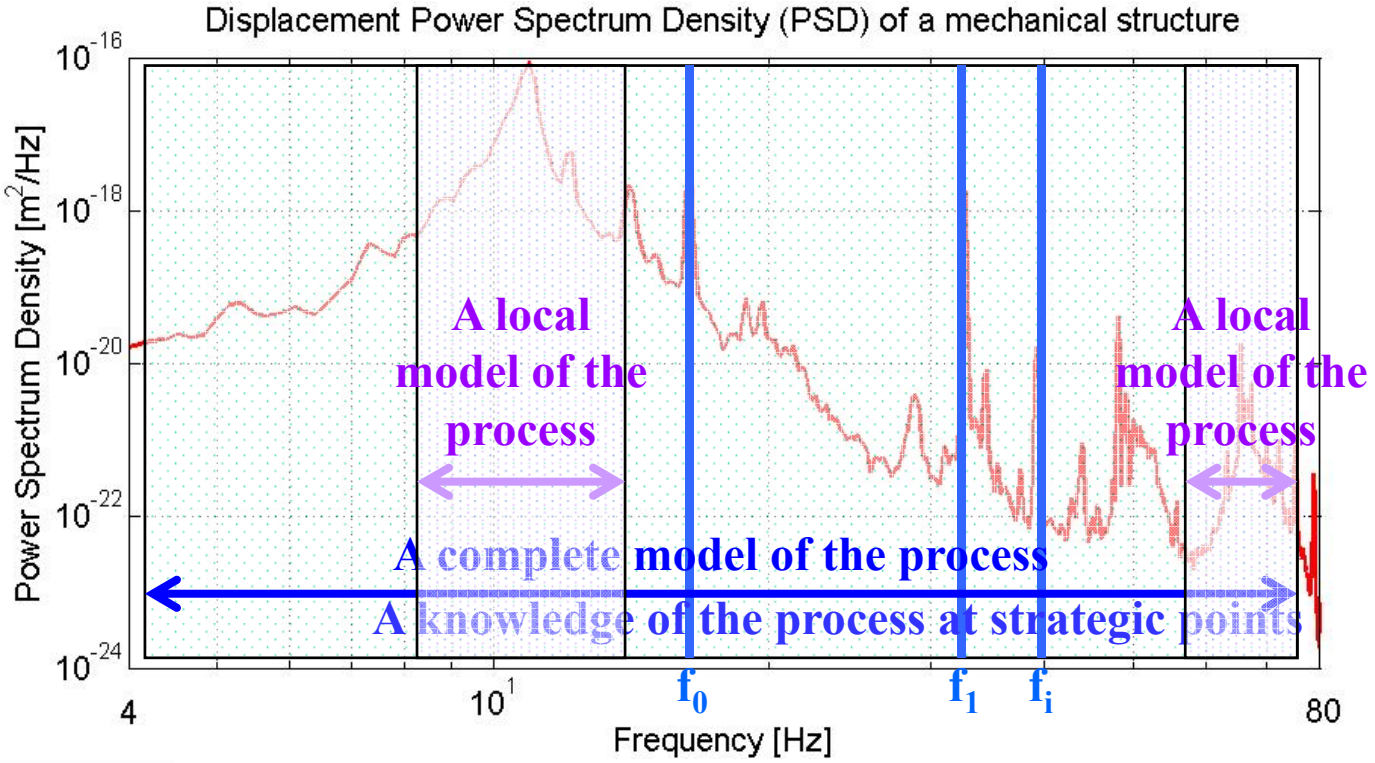
nm stabilisation equipment exists

Feedback loop

Another approach of the problem

L.Brunetti

✓ **Test an intermediary solution : to control a larger bandwidth**



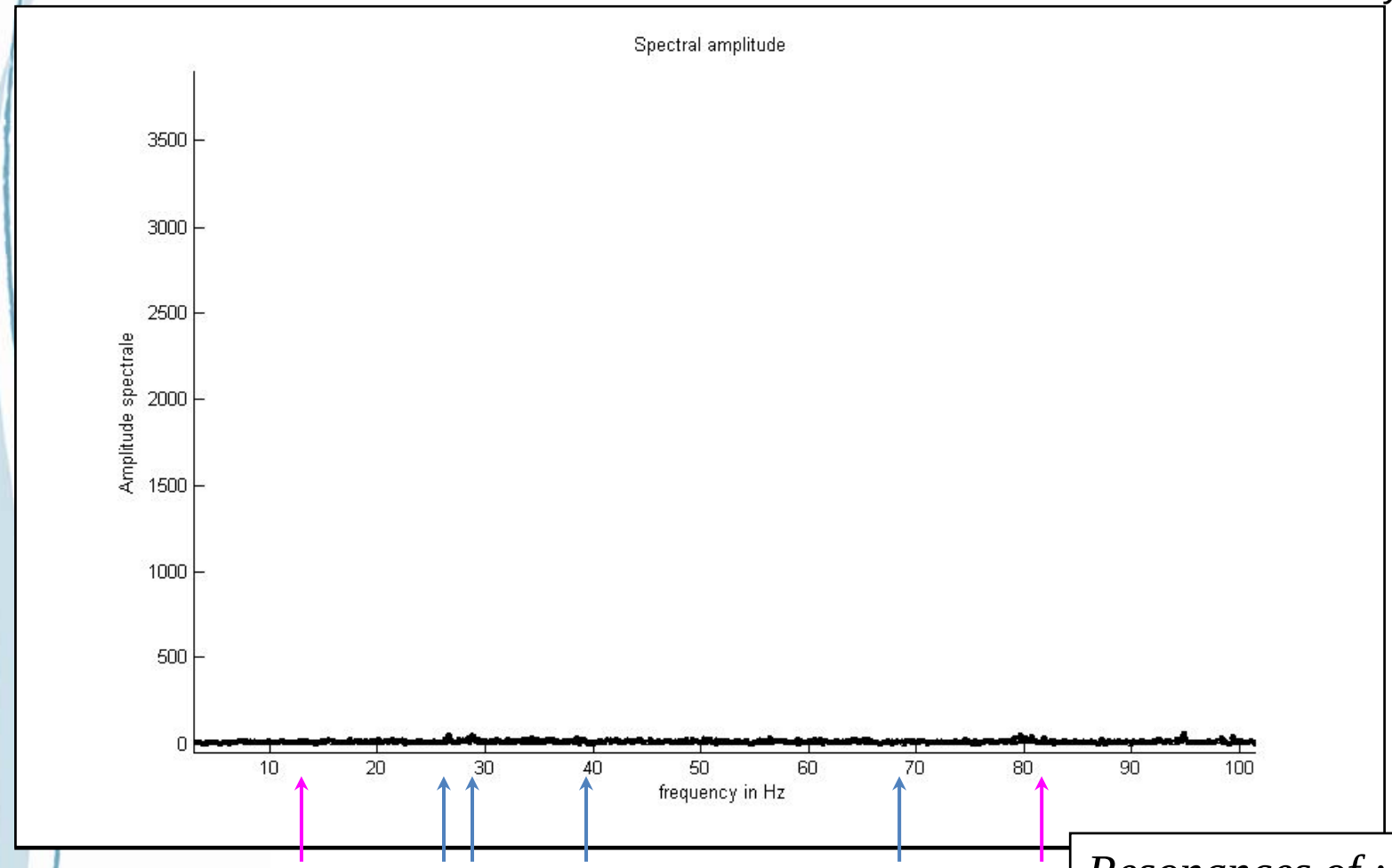
1 - A complete model of the structure : *too complex*

2 - A knowledge of the structure at strategic points : *the initially developed algorithm*

3 - A local model of the structure : *for the disturbances amplified by eigenfrequencies.*

Results

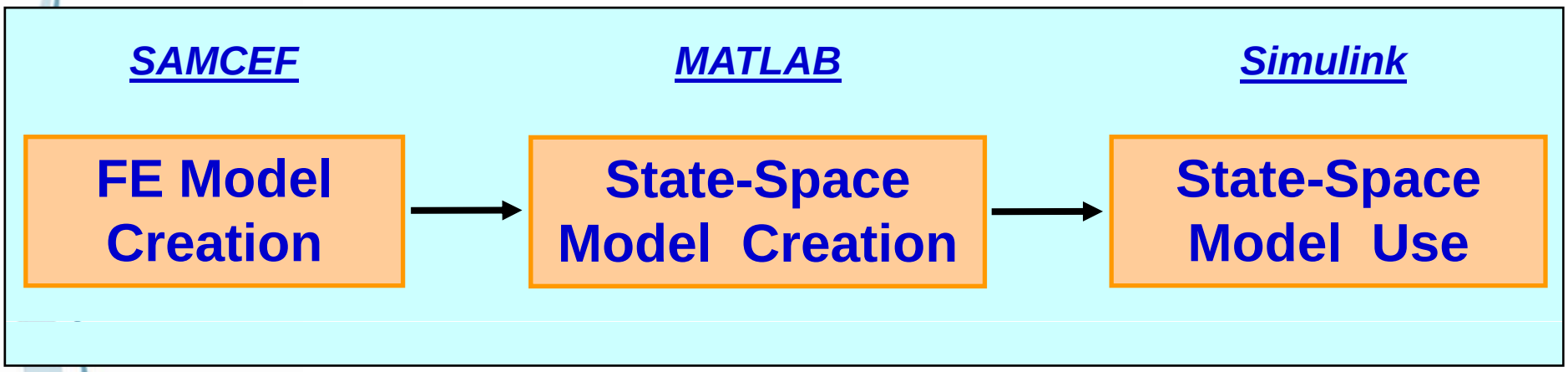
Rejection of 6 resonances : (without and with rejection) by L.Brunetti



Resonances of : *-beam*
-support

Tests in simulation

✓ **Integration of a finite element in a feedback loop :**



$$\mathbf{M}\,\ddot{\mathbf{u}}(t) + \mathbf{C}\,\dot{\mathbf{u}}(t) + \mathbf{K}\,\mathbf{u}(t) = \mathbf{f}_p(t)$$

M : mass matrix

C : damping matrix

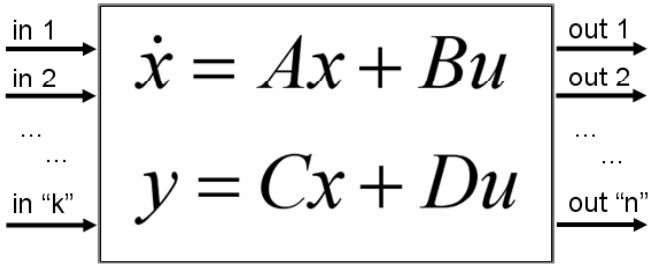
K : stiffness matrix

$$\dot{x} = Ax + Bu$$
$$y = Cx + Du$$

x : state vector

u : input vector

y : output vector

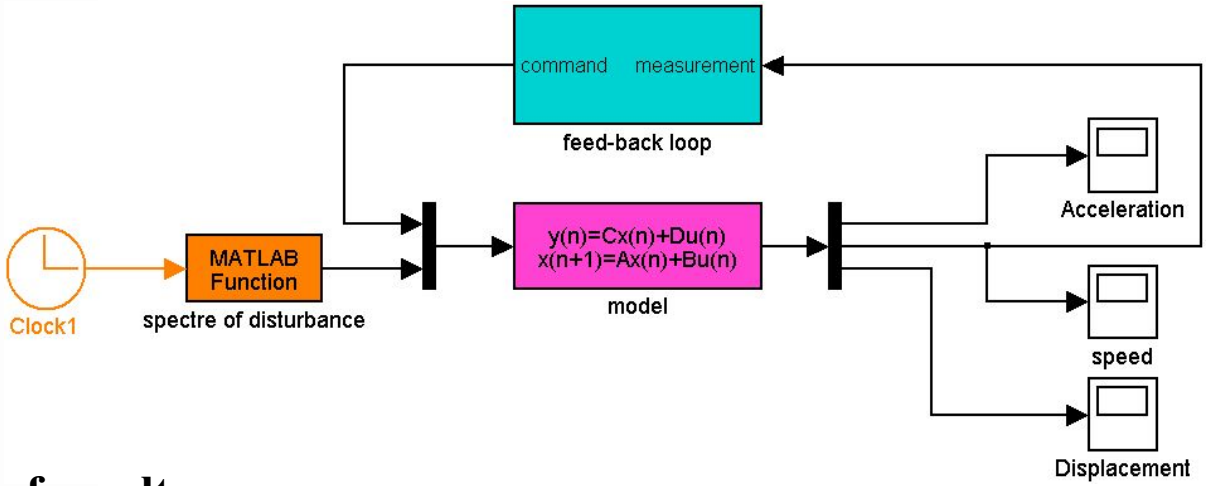


in : accel / force perturb. + force actuator

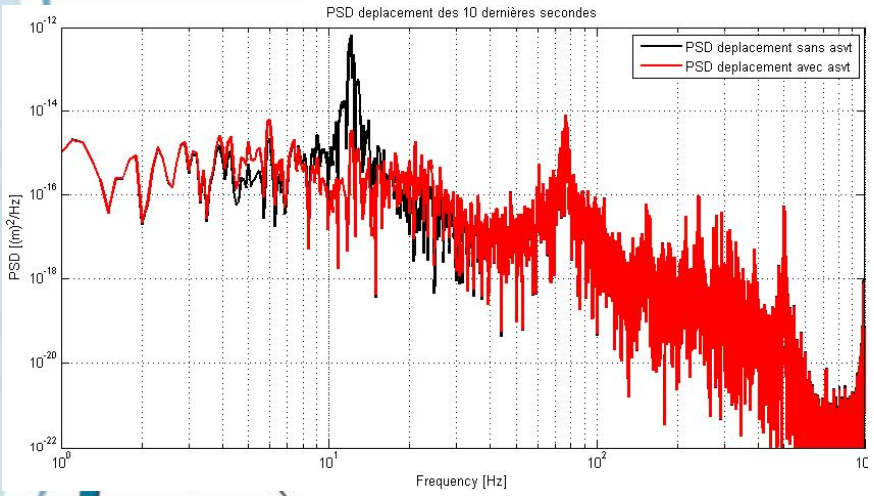
out : accel / velocity / displacement

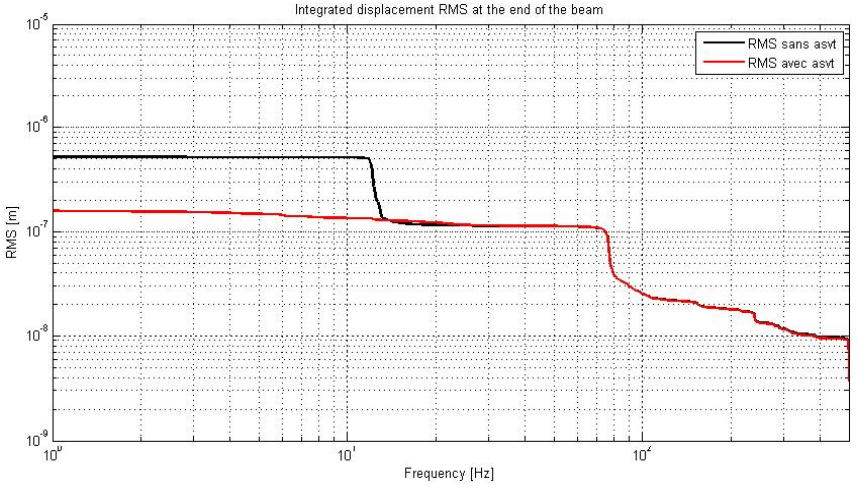
Tests in simulation

- ✓ **Integration of the finite element model in the feedback loop :**



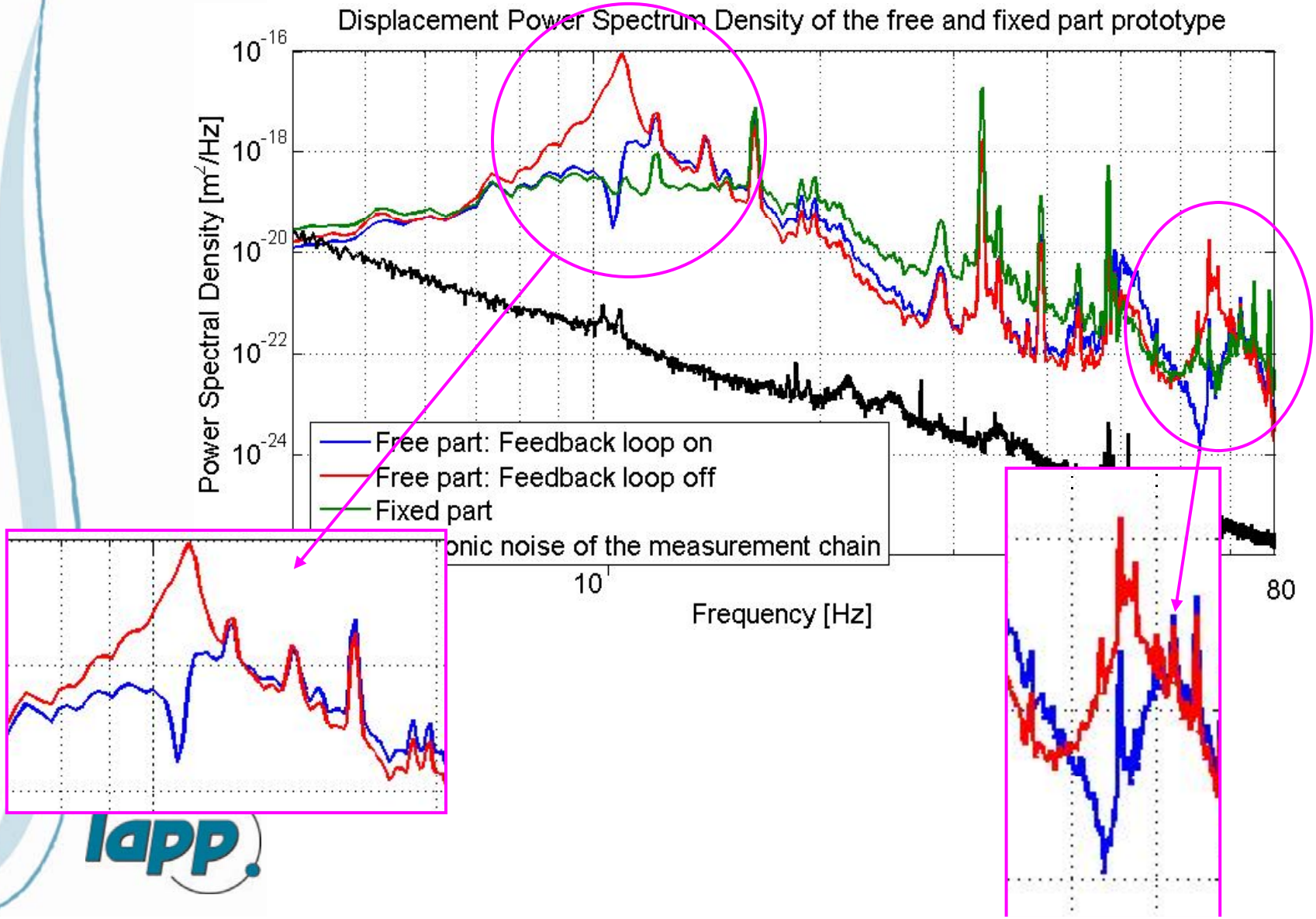
- ✓ **Example of result :**





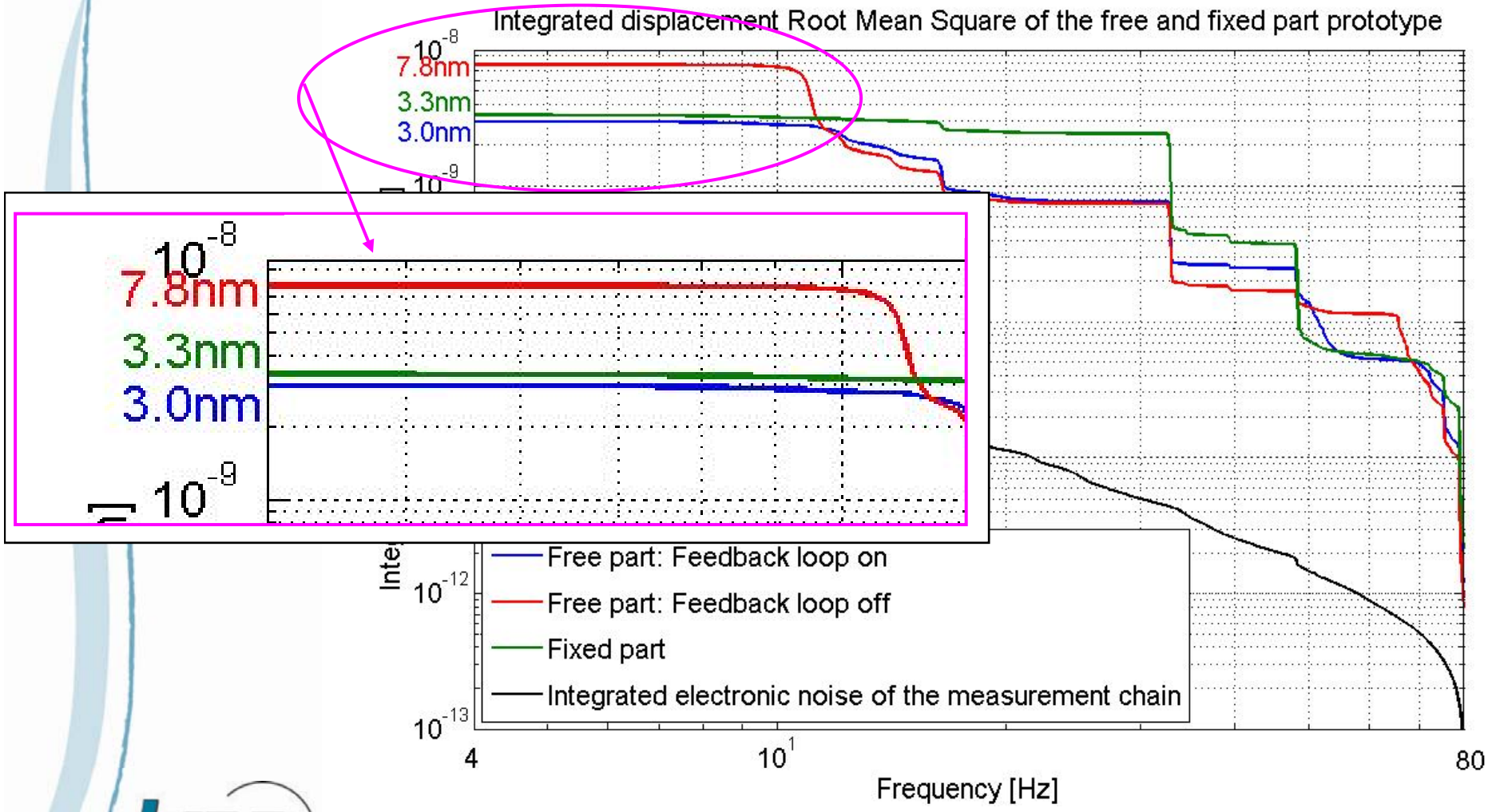
Tests with the large prototype

✓ Results : Power spectral density



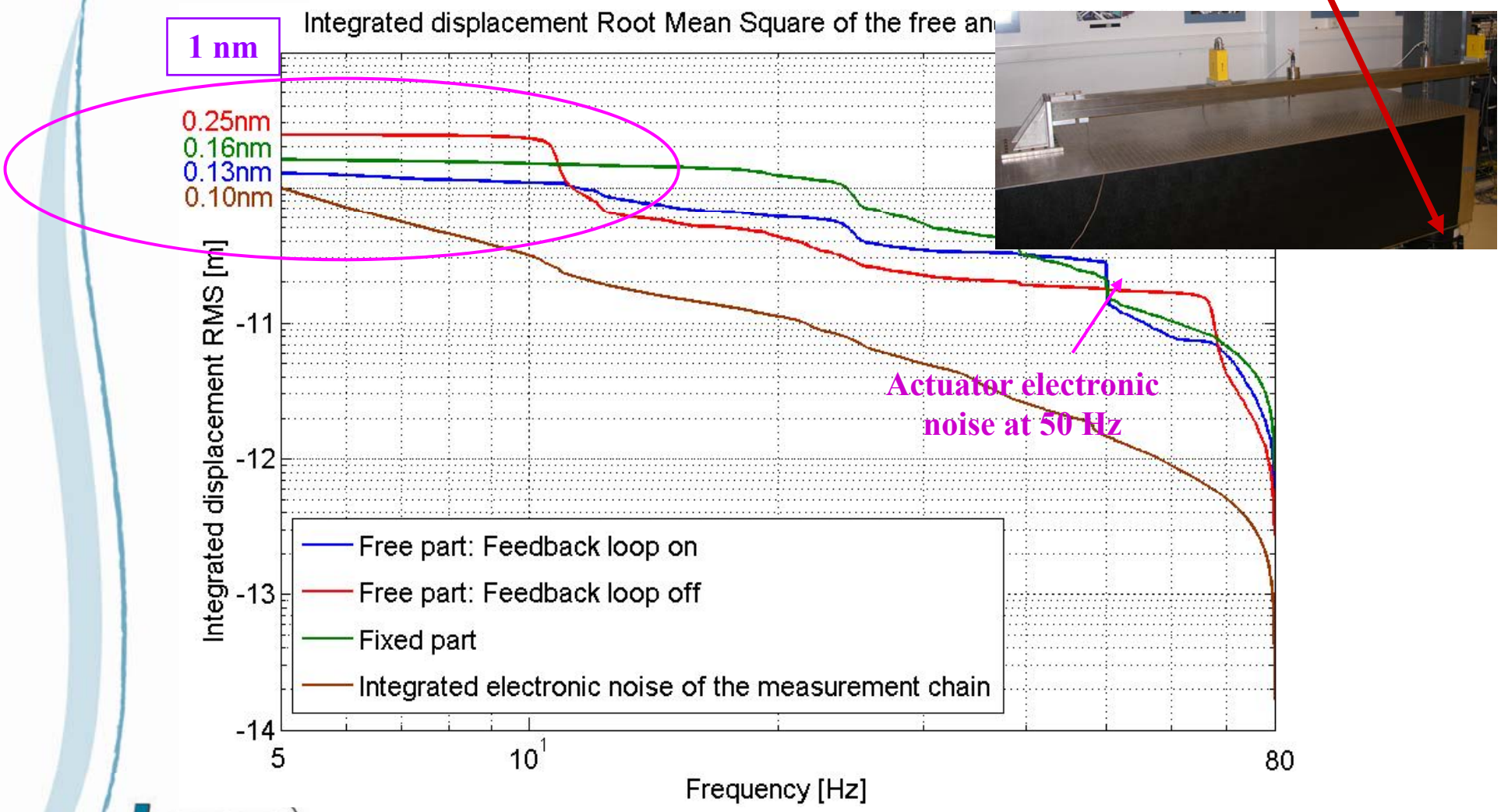
Tests with the large prototype

✓ **Results : integrated displacement RMS**



Tests with the large prototype: quiet room

integrated displacement RMS (with active table ON)



Combining isolation and compensation

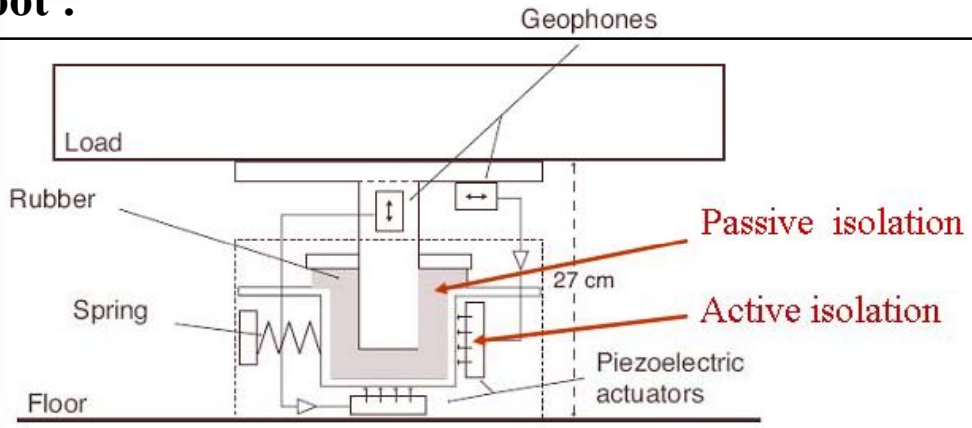
Combine passive and active stabilisation

Reasons of this study and the STACIS feet

✓ In the case of a possible partnership, we have no competence about active isolation.

✓ In the case of the development of a low cost table (this one is very expensive), we have no information about the mechanism (mainly the feedback loop).

✓ **STACIS foot :**



(Thesis of S. Redealli)

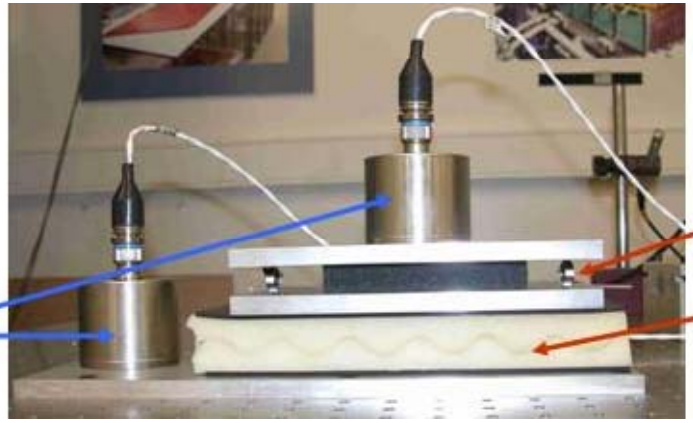
- Passive isolation : attenuates all the high frequency disturbances but amplifies the low frequency disturbances (like a resonant filter).

- Active isolation : attenuates the disturbance amplified by the passive isolation (low frequencies disturbances).

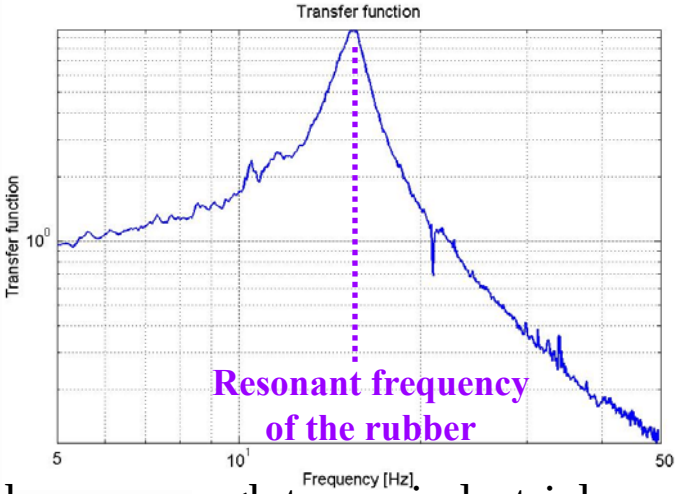
➢ **Test of active isolation on a small mock-up…**

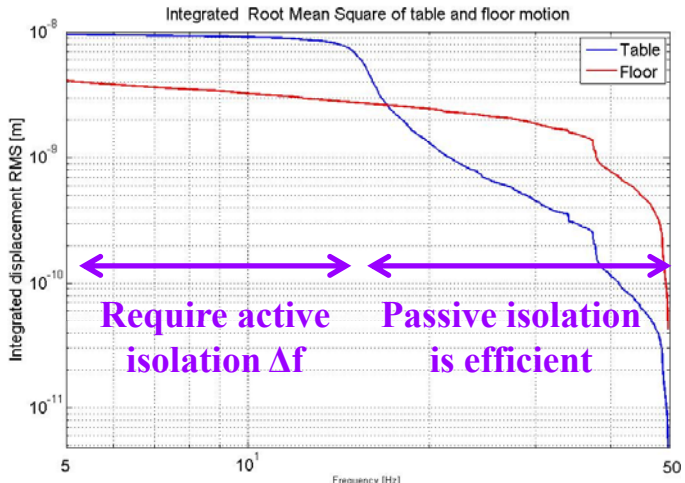
The small and elementary mock-up

✓ **Association of active and passive isolation :**



✓ **The passive layer :**



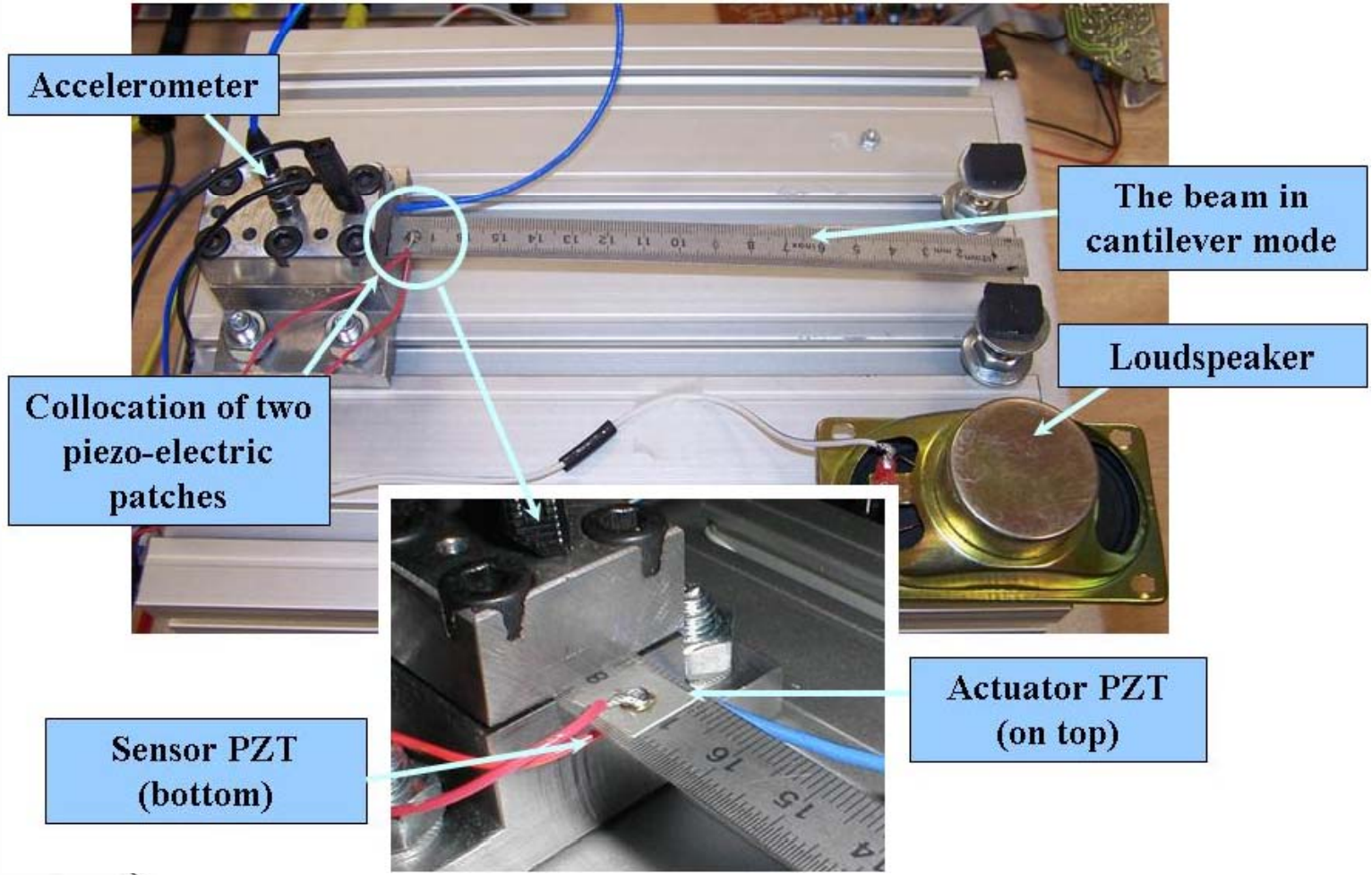


→ Not heavy enough to use industrial products, but it is possible with a larger prototype.

Multipoint stabilisation

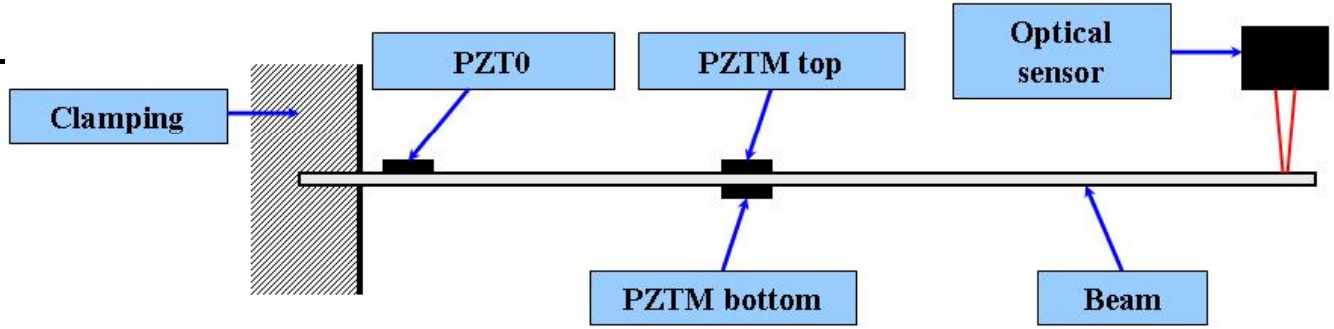
Test the algorithm with a small prototype

Description of the prototype :



Small mock-up

The prototype :



Experimental results :

Actuator	Sensor	PZT0	PZTM	Optical
PZT0	PZTM		***VG***	*G*
PZT0	Optical		*G*	***VG***
PZTM	PZT0	***VG***	*VB*	*G*
PZTM	PZTM	*N*	***VG***	*N*
PZTM	Optical	*G*	*VB*	***VG***

Very bad | No effect | Good | Very good

The rejection always works at the measurement point of the feed-back.

The behaviour of the beam changes with the configuration.

Conclusions

✓ **Hardware :**

- Acquisition chain able to measure at a nanometre scale
- Actuators to create nanometre displacements
- A real time solution to run automatics algorithm

✓ **Control :**

- 2 types of algorithms for active compensation
- A beginning of study for active isolation

➢ We have succeeded in stabilizing an elementary structure at a nanometre scale with a natural environment (some EUROTeV reports)

➢ PhD Benoît Bolzon in November 2007

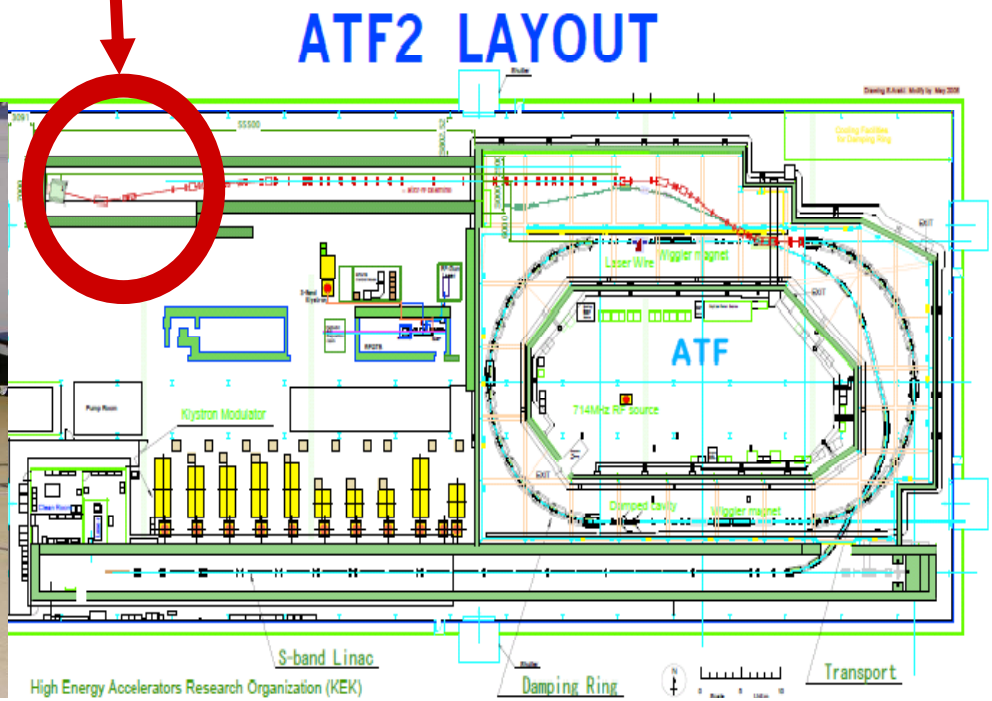
✓ **Future prospects :**

- The purpose now is to obtain the best possible stabilization all along the elementary mechanical structure (lower or equal to the imposed tolerance)

lapp

“spin-off” of EUROTeV

- We’ve been asked to contribute to the FD support study in ATF2 with our know-how of nanometre-level measurements and of stabilisation.



4.3.6.3 Milestones and expected result of this Work Package:

Date	Milestone
6 months	Detailed scope and planning report to First Workshop.
18 months	Presentation of results and detailed implementation at Second Workshop.
30 months	Presentation of phase 2 results to Third Workshop; plans for GDI-TDR input and further R&D (phase 3 and beyond).
30 months	LICAS RTRP prototype test programme complete.
36 months	Evaluation of mechanical stabilisation techniques complete.
36 months	Site ground vibration characterisation programme complete.

4.3.6.4 Deliverables of this Work Package:

Deliverable number	Deliverables	Dissemination level
1	Prototype mechanical stabilisation system.	PU
2	Prototype laser-based stabilisation system.	PU
3	3 and 5 car prototypes of laser-based RTRS system.	PU
4	Database (with public web interface) of catalogued and characterised ground vibration spectra.	PU

Plans for 2008

- Test the robustness of feedback algorithm
- Continue study on a multiple I/O feedback system
- Explore further into the “isolation” system
- Future within *EUCARD* : *Stabilisation* task in *NCLinac* WP => CLIC/CTF3 FF and Quadrupole module