CLIC stabilization

Beam line and final focus

Previous study

(Summary by S. Redaelli, 2004)

"The **goal** of the proposed study is to show that the **collision of nanometre-size beams** in CLIC is **feasible** in a real accelerator environment, using latest cutting-edge stabilization technology and time dependent simulation programs."

Stability of about 0.5-1nm has been demonstrated on a mock-up

TARGET (FP7)

(Daniel Schulte)

- Demonstrate 1nm quadrupole *(1400)* stability above 1Hz
- Demonstrate 0.1nm stability above 5Hz *(final focus)*
- Differences compared to previous studies
  - 0.1 nm is beyond what we have shown
  - apply stabilization in an accelerator environment
  - achieve 1nm with realistic equipment not simple elements on a special table
  - verify performance with two different methods
- Characterize noise sources in an accelerator

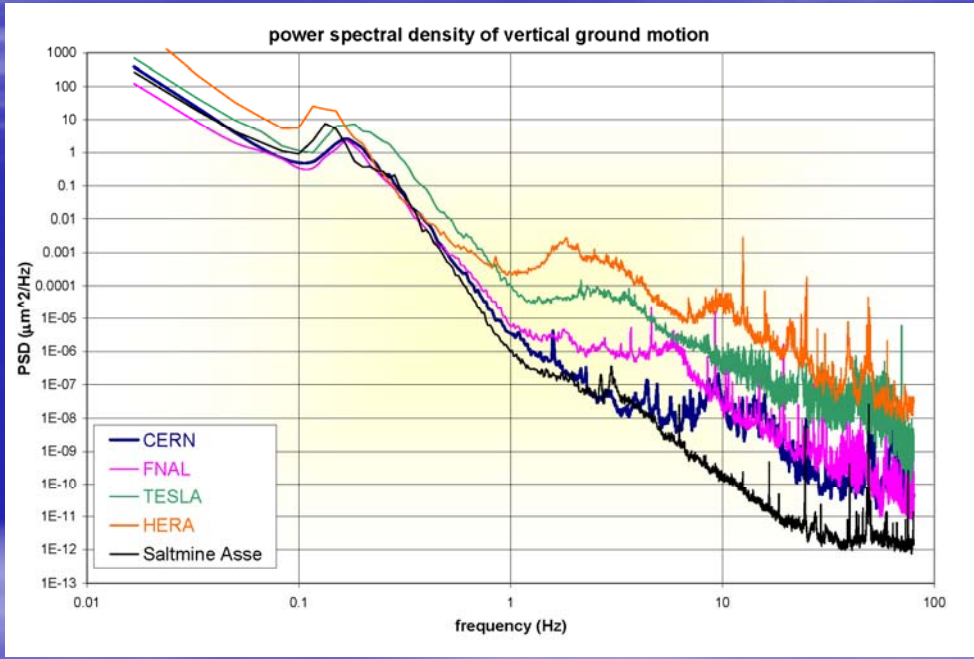
Sources of the problem

- Vibrations
  - Natural (Earth)
  - Occupational (Noise, Fluids)

Natural (Earth)

Metrology: site measurement & characterization

by R. Amirikas and A.Bertolini
DESY



Power spectral densities for five measured sites

- **Study the impact of 'cultural noise' @ f >1 Hz, at several accelerator laboratories & synchrotron light sources**
- **19 sites are measured so far. Database available: http://vibration.desy.de**
- **Same equipment and data analysis tools are applied to each case; Therefore, direct comparison is possible**
- **This work will continue albeit with a lower priority, often combined with other measurements**
- **Publications: presentations in Nanobeam2005 (EuroTeV report-2005-023) and EPAC06 contribution, in preparation**

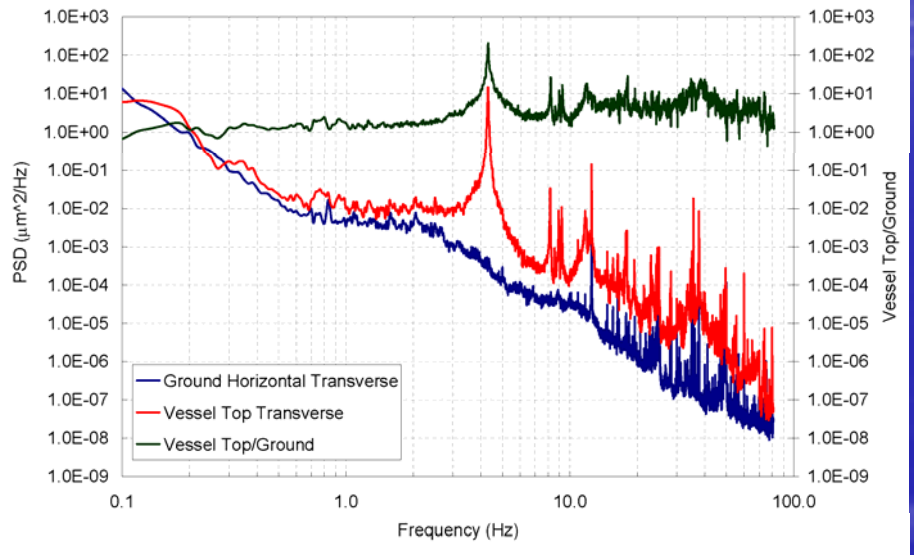
CERN is a good location!

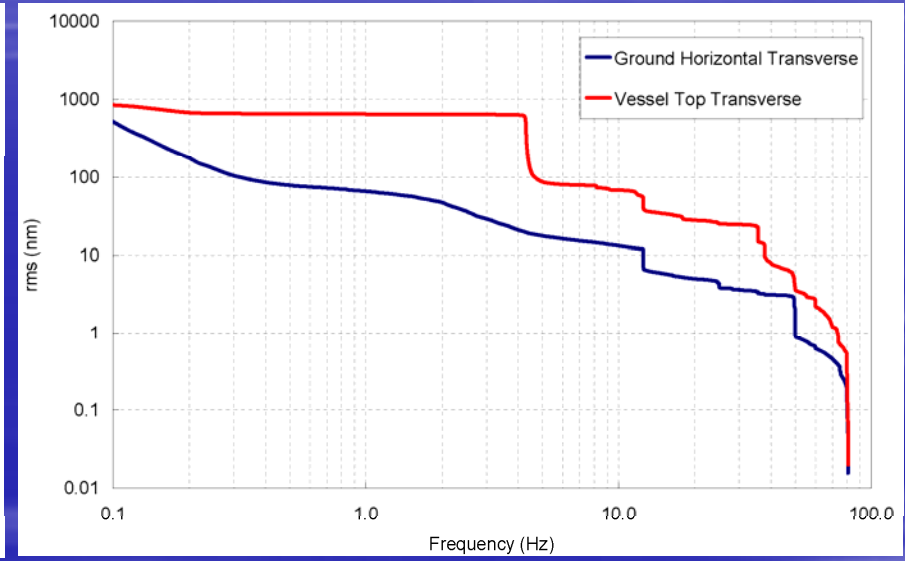
Exemple of instability of accelerator components:

Measurement of the stability of a 'warm' cryomodule (Type II Superstruktur)

by R. Amirikas and A.Bertolini
DESY

Ground to vessel top (transverse to the beam direction)





PSD in transverse direction to the beam pipe as measured via seismometers, Vessel top vs. Ground, Vessel resonances: ~4.3, 8.0, 9.0 Hz; vessel rocks due to bad girder support (in this case concrete slabs) & steel pads

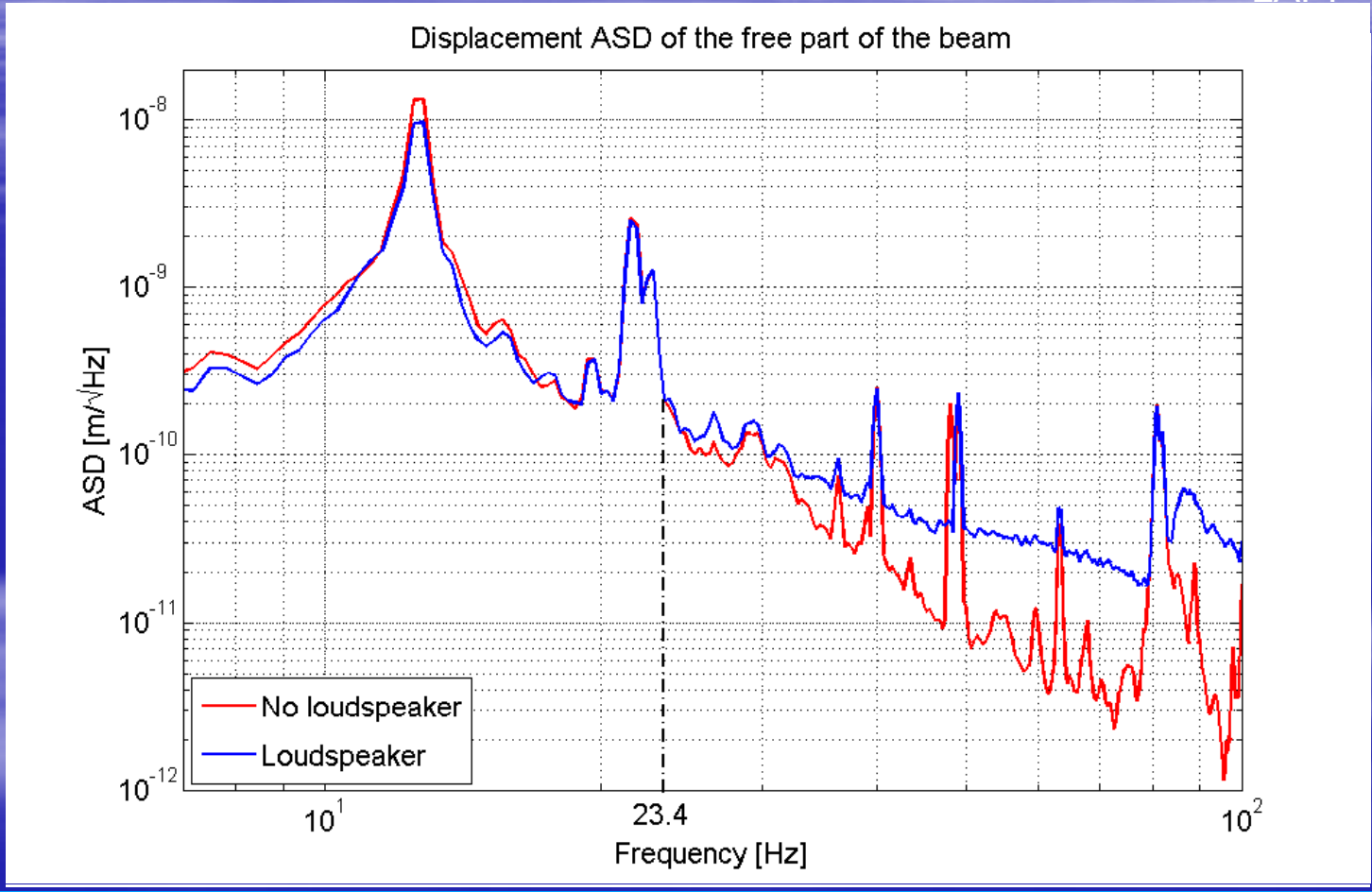
Integrated transverse vibration for f>1Hz as measured via seismometers, amplification @ 1 Hz: Top/Ground~ 10

Amplification factor for Ground/Quad = Top/Ground*Helium/Top*Quad/Helium =10.0*0.80*1.06= 8.48 ~10

Occupational: Noise

Impact of the loudspeaker on the vibrations of the beam

by B.Bolzon
LAPP



✓ **Above 23.4Hz :** Vibrations of the beam higher with the loudspeaker

Occupational: Noise

Impact of the loudspeaker on the vibrations of the beam

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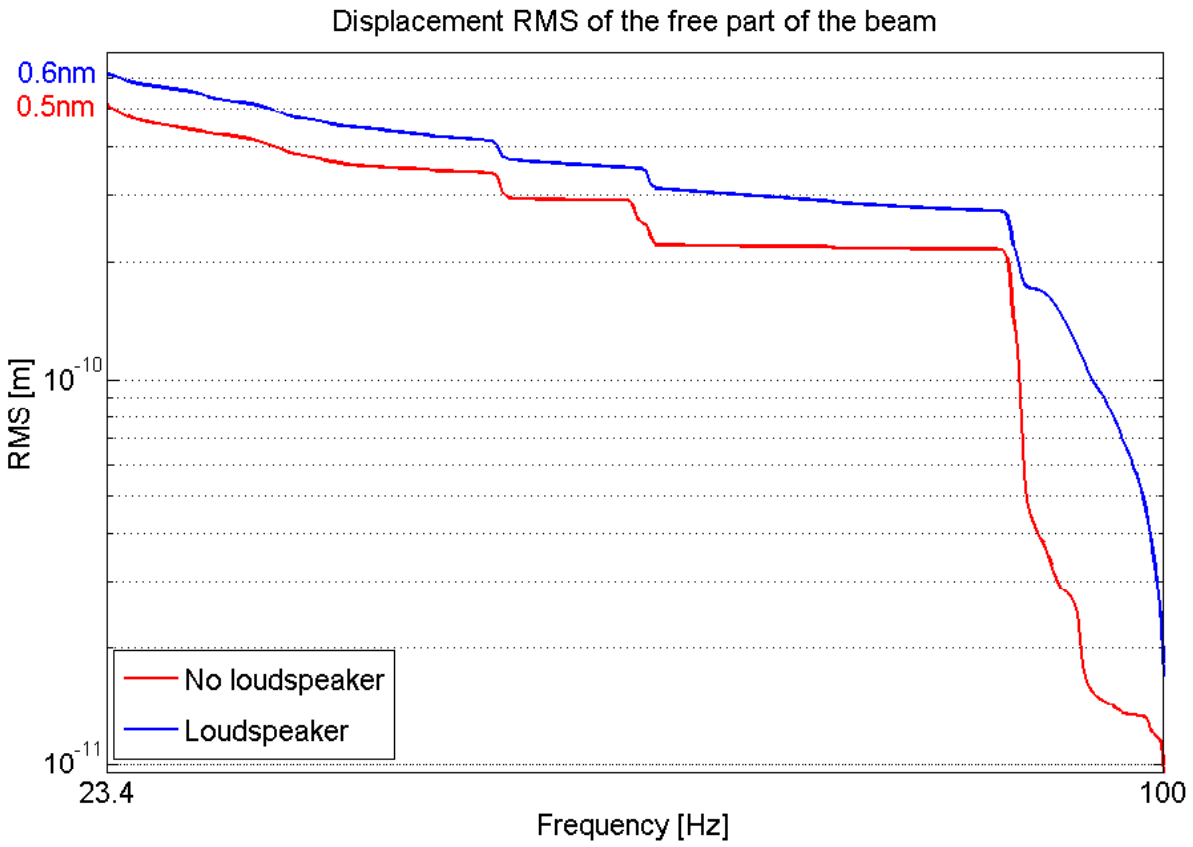
LAPP



Very small increase of acoustic pressure : 44dB→53dB

Small increase of the beam displacement : 0.1nm

✓ For sure, impact of acoustic pressure on the vibrations of a free-fixed beam

✓ But need of more measurements to evaluate if this impact is important

Principles of the solution

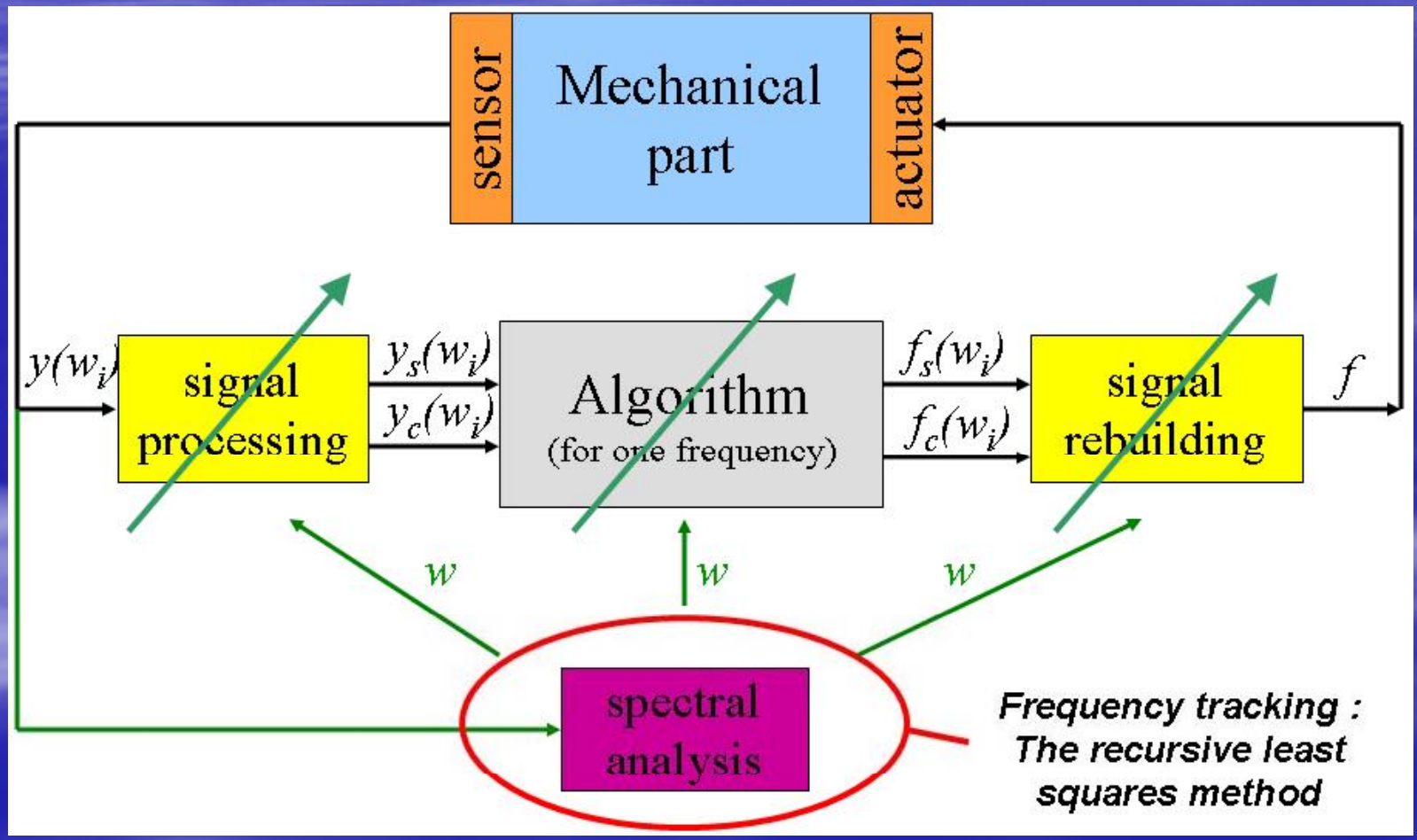
- Measure the perturbations: sensor
- Calculate the corrections: feedback
- Apply the corrections: actuator

But multi degrees of freedom and minute displacements…

Signal processing

by L.Brunetti LAPP

- As each frequency is rejected independently, the robustness depends on the estimation of the real value of the disturbance frequency :



Sensors

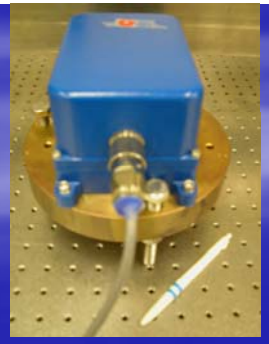
Sensors available at LAPP

2 types of sensors :

→ **Velocity sensors :** Floor velocity measurement

→ **Accelerometers :** Floor acceleration measurement

Sensor	VE-13	Guralp CMG-40T	SP500B	393B12	ENDEVCO 86
Sensitivity	10000V/m/s	1600V/m/s	2000V/m/s	10V/g	10V/g
Frequency range	1 - 315 Hz	0,033 - 50 Hz	0,0167 - 75 Hz	0,1 - 4kHz	0,01 - 100 Hz
Electronic noise	1.7nm	0.07nm	0.085nm	24.2nm	0.6nm
Quantity	2	2	2	2	2



- Electronic noise high
- Big sensor

- Low electronic noise
- Big sensor

Non magnetic

- Low electronic noise
- Small sensor

- Very high electronic noise
- Small sensor

The best « industrial » sensor

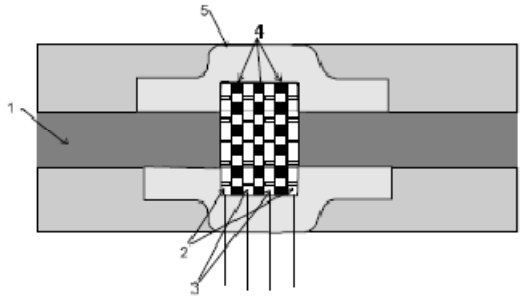


FIGURE 1: MET TRANSDUCER

1 - Electrolyte channel
2 - Platinum mesh anodes
3 - Platinum mesh cathodes
4 - Microporous spacers
5 - Housing

Electrochemical motion sensor

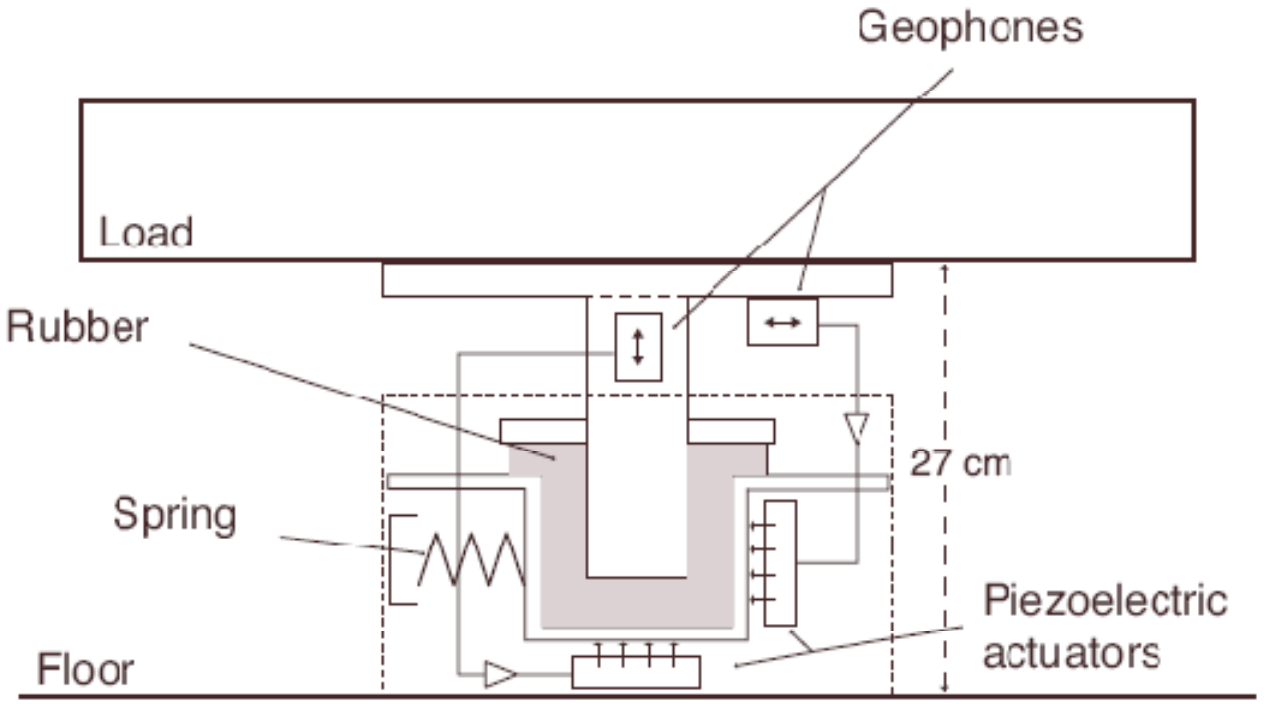
- Special electrolytic solution
- Four platinum mesh electrodes (2 anodes and 2 cathodes)
- An external acceleration creates a differential pressure across the channel and forces the liquid to move with velocity V. Ions move to the electrodes .

- 0.0167 to 75 Hz
- Non magnetic
- 20KV/(m/s)→very sensitive!!

SP500 sensors from EENTEC

PMD scientific has promised to send us 2 prototypes; conditions not yet finalised => work together on sensor development

Actuator: CERN table presently at LAPP

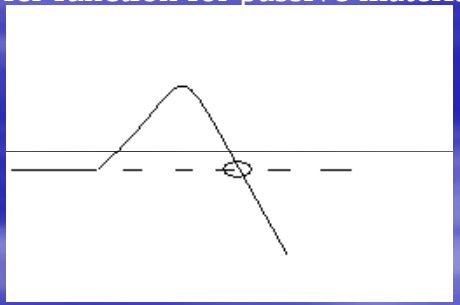


- « Passive » rubber:

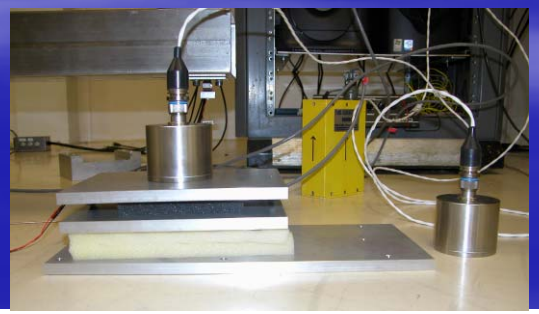
  - Enhance the perturbation around a given frequency f_c

  - Damp perturbations above f_c

Transfer function for passive material



- « Active » :- Active isolation in the frequency range enhanced by the passive material



=>start building a prototype combining Passive and Active isolation

Actions list
Potential R&D

Apply to quadrupole stabilization (series production) and to final focus (technological limit).

- Overall design
  - Compatibility of linac supporting system with stabilization: eigenfrequencies, coupling between girders, coupling of mechanical feedback with beam dynamics feedback,…
  - Integration of all the final focus features: types of supporting structures, coupling with vertex detector, …
- Sensors
  - Develop sensors or rely on industry. (Collaboration?)
  - Calibrate by comparison. Use of interferometer. Create a reference test set-up (at CERN?).
- Actuators
  - Understand the behaviour of the CERN table. Acquire a second one with dimensions better adapted to the final focus.
  - Develop and test various damping techniques (passive and active)
- Feedback
  - Develop methodology to tackle with multi degrees of freedom (large frequency range, multi-elements)
  - Apply software to various combinations of sensors/actuators
- Integrate and apply to linac and final focus prototypes

Manpower CERN

(dependant of the role CERN wants to play inside the collaboration)

Passive (basically support design) assumed to be taken into account by the Module Design team

Active:

Multi-disciplinary.

Measurements and signal treatment of sensors and actuators on set-up/equipment

Specialities: mechanics, electronics, signal analysis

Manpower:

Mechanical engineer 0.5 fte/year *

Electronical engineer 0.5 fte/year

Programming engineer (signal processing) 0.5 fte/year

Technicians in mechanics/measurements/electronics 1.5fte/year*

* can be found in TS (but not assigned in the MTP)