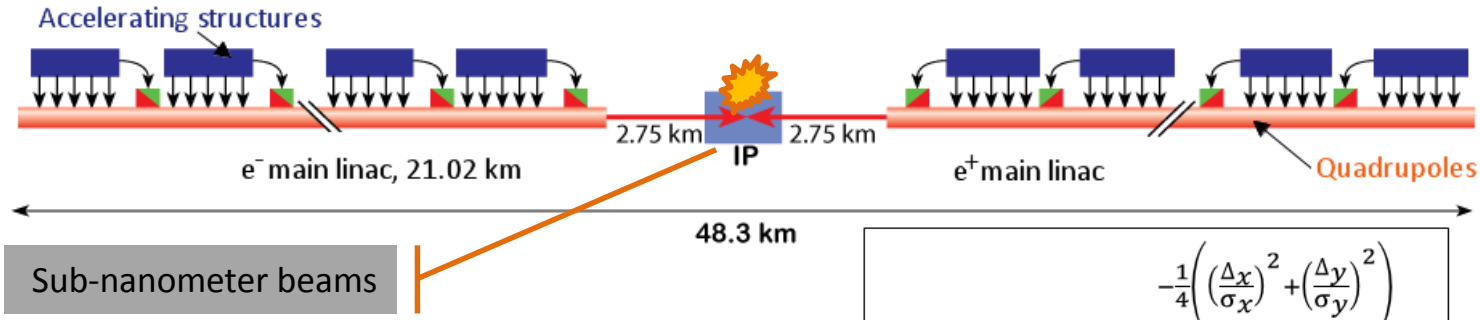
CLIC QD0 stabilisation progress

L. Brunetti[1], B. Aimard[1], J.-P. Baud[1], G. Balik[1] , A. Jeremie[1], B. Caron[2], (LAViSta Team)

[1]: LAPP-IN2P3-CNRS, Université de Savoie, Annecy, France
&
[2]: SYMME-POLYTECH Annecy-Chambéry, Université de Savoie, Annecy, France

CLIC Challenge vs QD0 stabilization

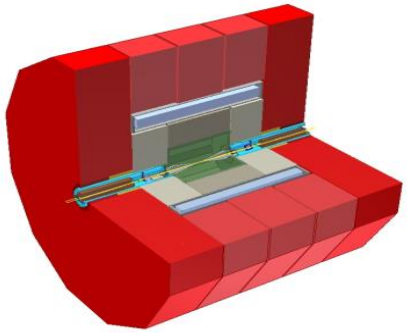
- ***Final focus CLIC R&D:***



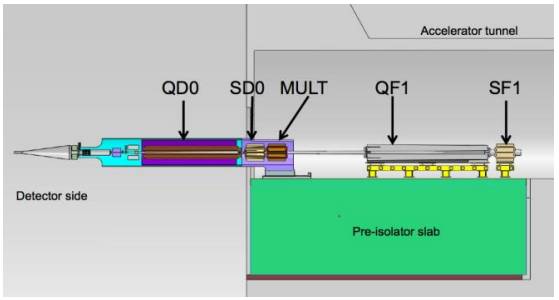
$$L(\sigma_{x,y}, \Delta_{x,y}) \sim \frac{e^{-\frac{1}{4}\left(\left(\frac{\Delta_x}{\sigma_x}\right)^2+\left(\frac{\Delta_y}{\sigma_y}\right)^2\right)}}{\sigma_x \sigma_y}$$

- ***Developments of LAViSta team are dedicated to the final focus***

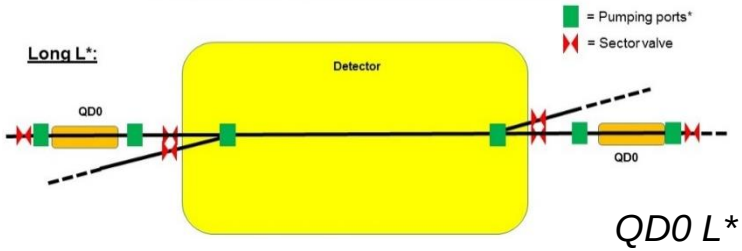
Vertical beam offset: 0,2 nm RMS @ 0,1Hz



CLIC detector



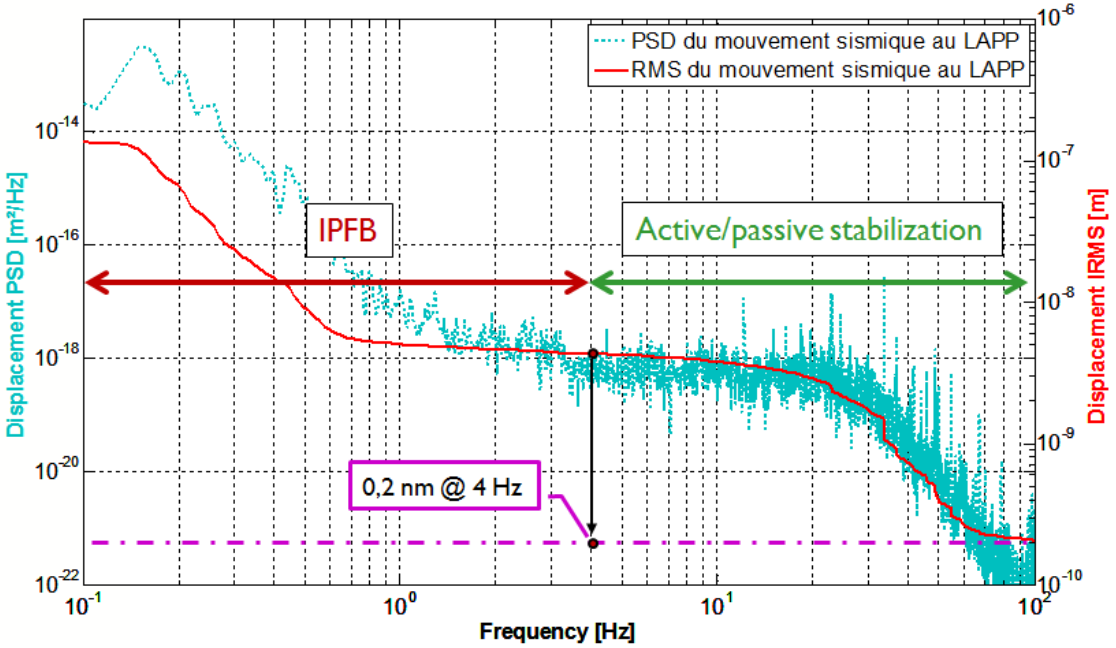
QD0 Cantilever



*QD0 L**

Introduction

- ***Final focus : beam stabilization strategy***



➢ At the IP (mechanical + beam feedback), we aim a vertical beam offset at **0,2nm at 0,1Hz**

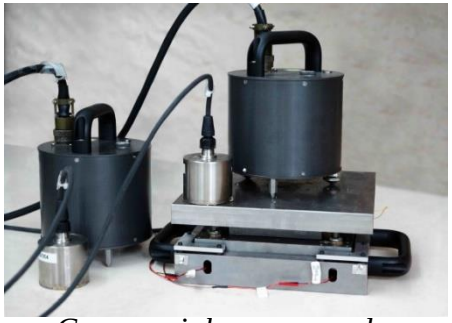
- **IPFB :** Interaction Point beam based FeedBack is already developed in collaboration with CERN since 2010

  - Caron B et al, 2012, "Vibration control of the beam of the future linear collider", Control Engineering Practice.
  - G. Balik et al, 2012, " Integrated simulation of ground motion mitigation, techniques for the future compact linear collider (CLIC) ", Nuclear Instruments and Methods in Physics Research

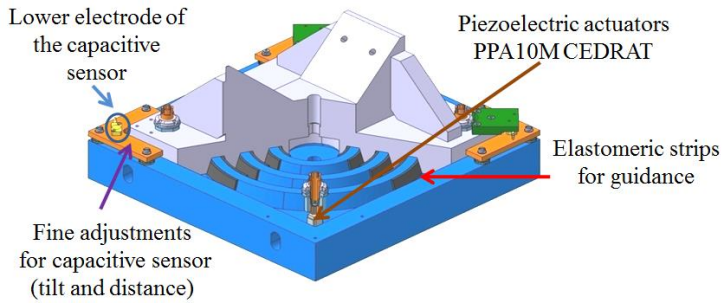
- **Active / passive stabilization : has to be achieved ("Mechanical stabilization")…**

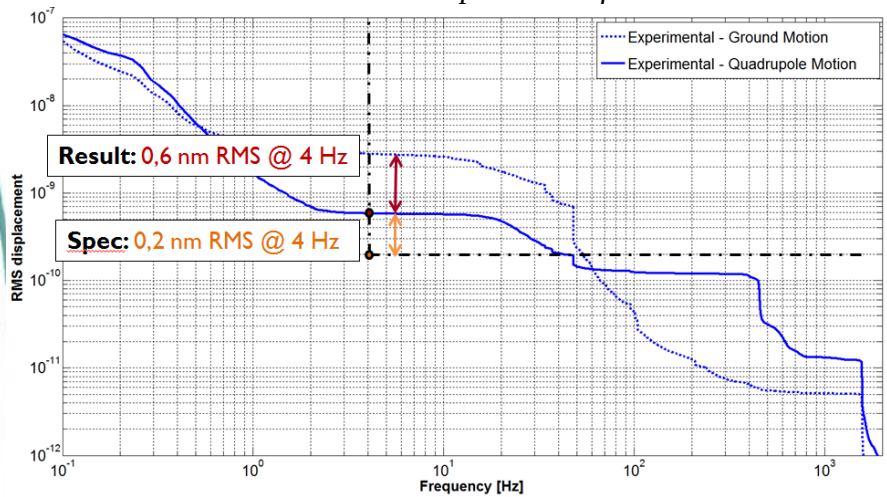
Active control : demonstration

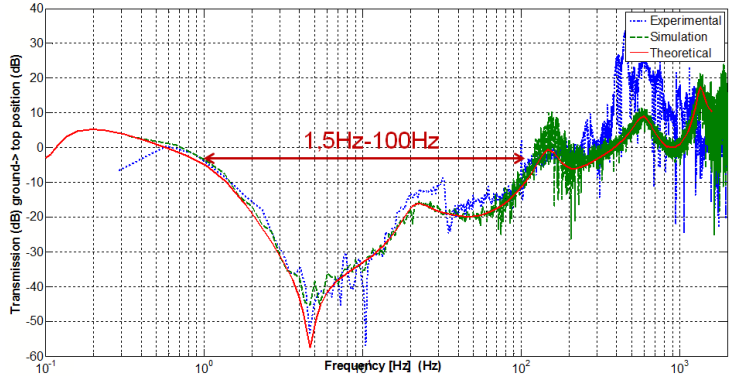
- ***Prototype of active control system :***



Commercial sensors and a developed active foot







- **Results with commercial sensors : 0,6 nm RMS@4Hz.**

- Balik et al, "Active control of a subnanometer isolator", JIMMSS, 2013.
- R. Le Breton et al, Nanometer scale active ground motion isolator, Sensors and Actuators A: Physical, 2013.

- *Sensors dedicated to measurement but not to control*
- *Two needed technologies for the selected bandwidth (geophones for low frequencies and accelerometers for high frequencies)*
  - ➢ *complexity of the control*

➢ ***Main limitation : SENSORS (Experimental and theoretical demonstration).***

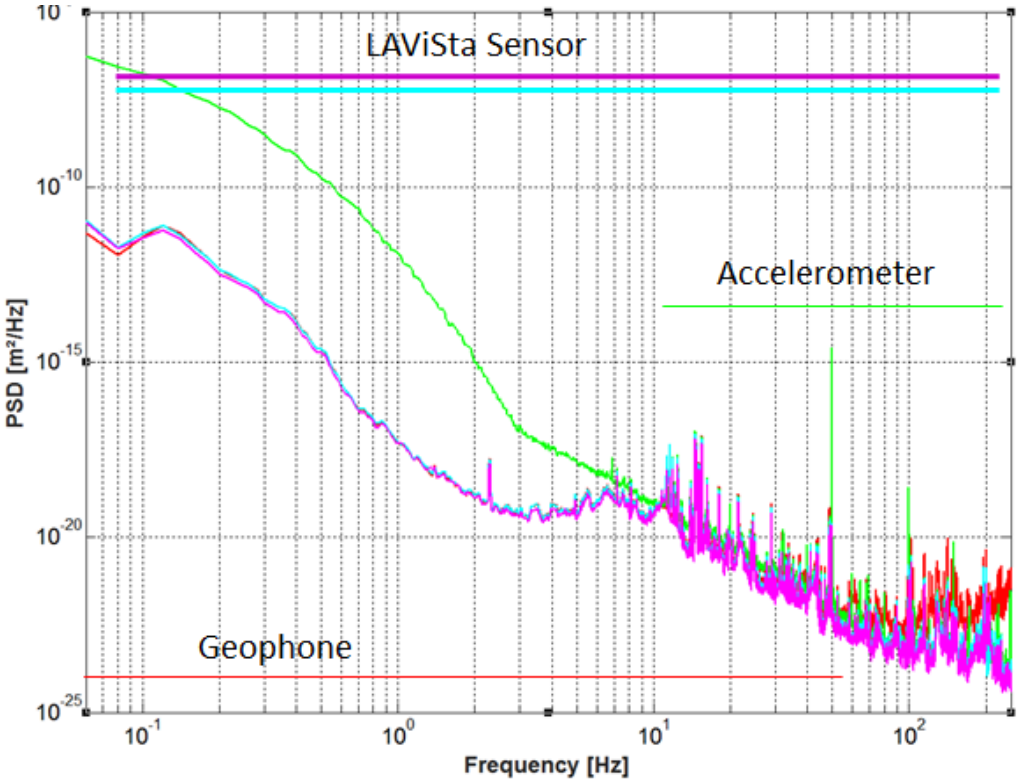
Sensors : Measurements on site

- ***Development of a new vibrations sensor:***

  - Approach validated → Patent n° FR 13 59336.

Prototypes developed since 2011

- ***Comparison with Güralp and Wilcoxon sensors at CERN (ISR):***



Geophone
(Güralp 3-ESP)
Low frequencies

Accelerometer
(Wilcoxon 731A)
Mid-High frequencies

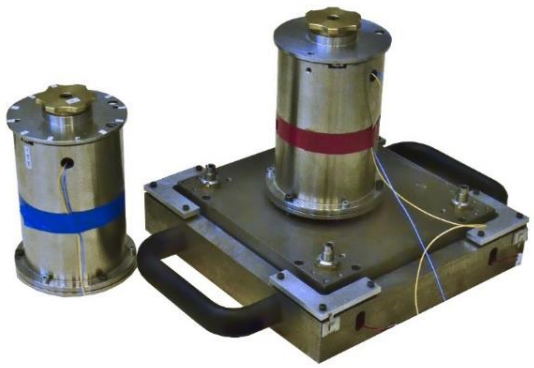
LAViSta sensor
(x2)
Large bandwidth

Active control to the developed sensors

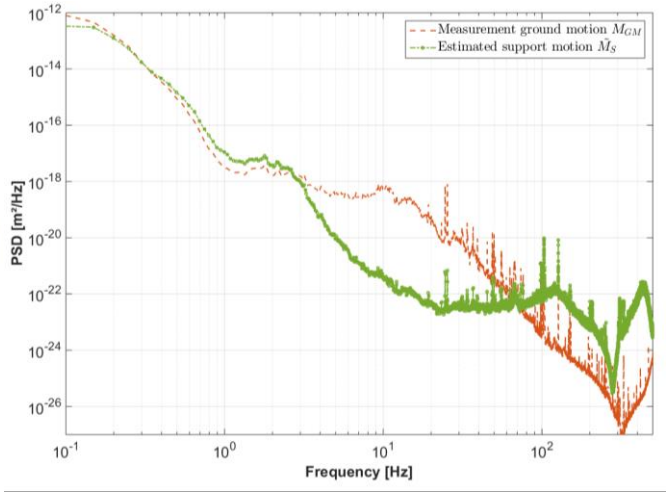
- ***2016 : CLIC Demonstration of faisability at reduced scale***
  - CLIC specification (displacement of the QD0 final focus) : 0,20 nm RMS@4Hz
  - Previous results with LAPP active foot + 4 commercial sensors : 0,60 nm RMS@4Hz

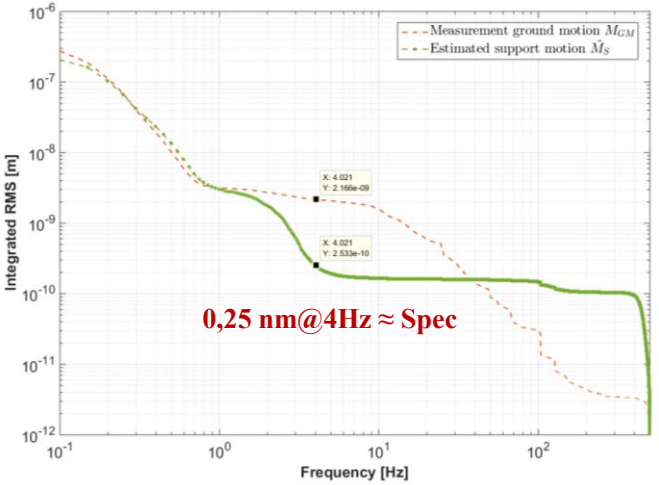
  ➢ **Results of control (autumn 2016) with LAPP active foot + 1 LAPP vibrations sensor : <u>0,25 nm RMS@4Hz</u>**

  - *Only 1 sensor in feedback -> control less complex and more efficient*
  - *Journal article submitted in beginning of 2017*



- LAPP active foot + LAPP sensors (one on ground used to monitor ground motion and 1 on top used in feedback) -

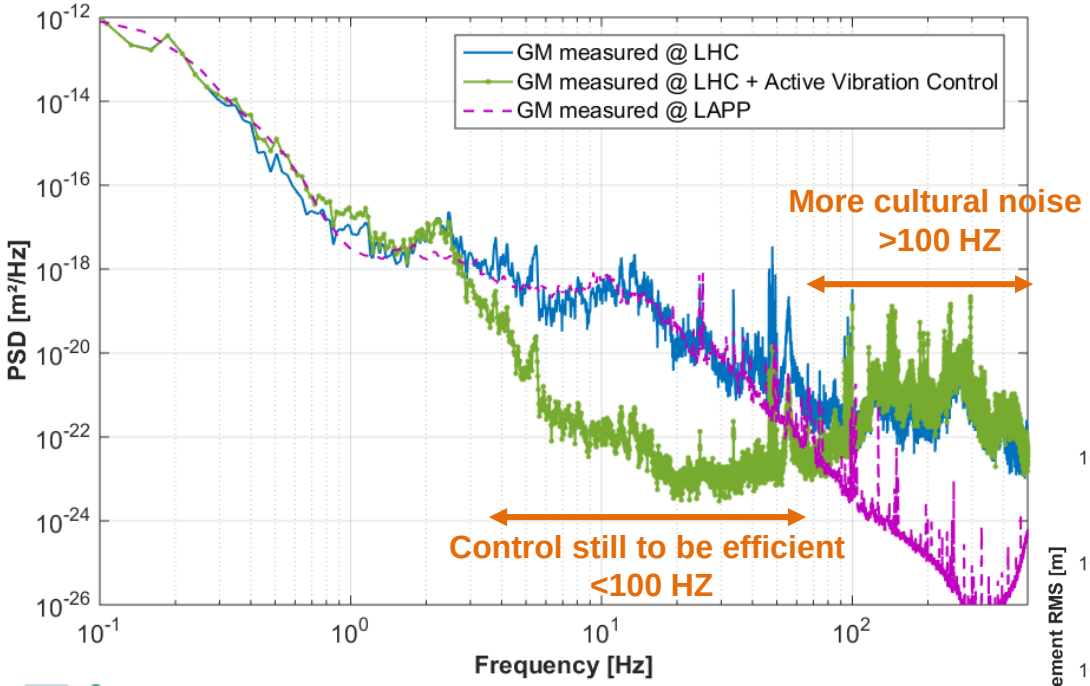




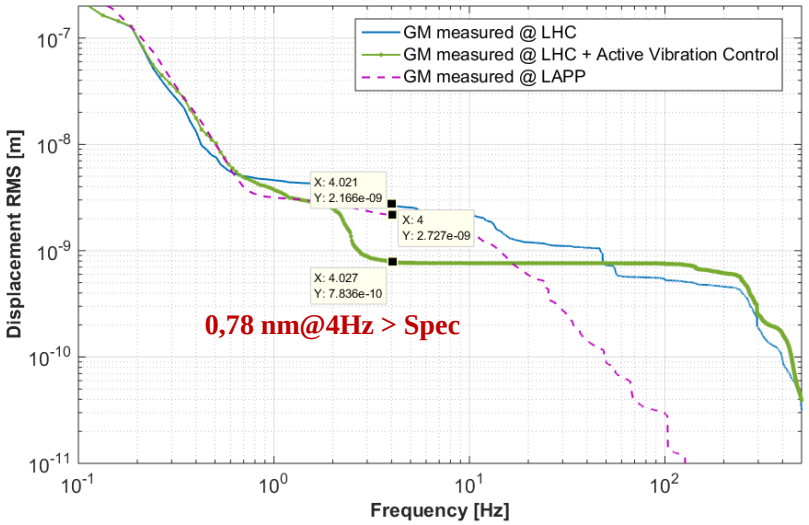
*- Displacement **without control** / **with control** **at LAPP** -*

Simulation of the active control with a collider environment

- ***CMS detector motion is taken into account (high level of cultural noise - pessimistic)***
- ***Simulation of the system (foot + sensors) with these disturbances***



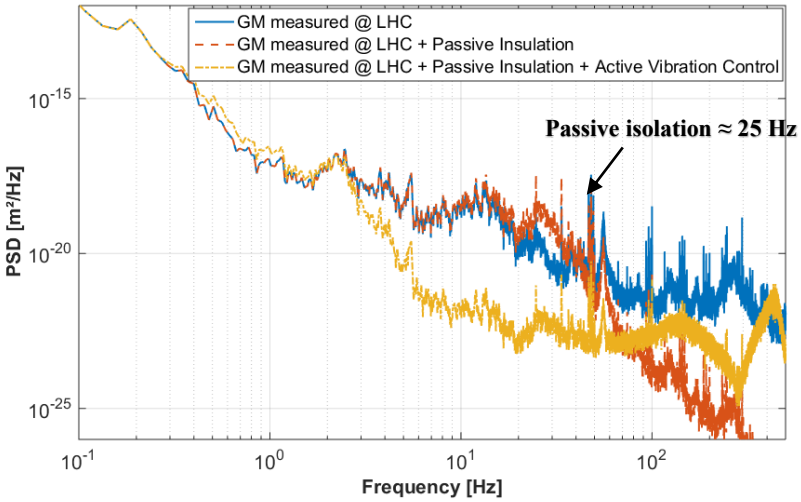
- *Disturbances don't reveal the same distribution (more cultural noise)*

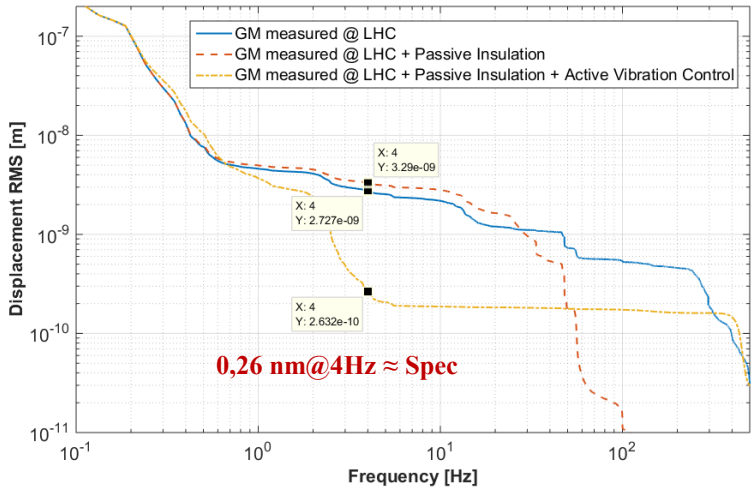


➢ ***Control is not efficient enough in this case (above 100 Hz)***

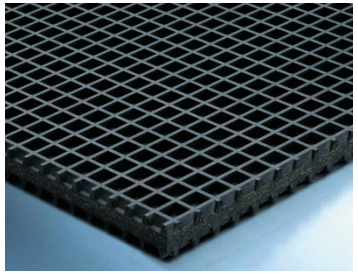
Simulation of the active control with a collider environment

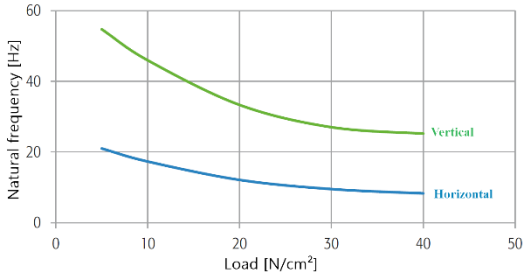
- ***Necessity to have a passive insulation under the concrete or under the last elements***





- ***A passive insulation at about 25 Hz is common to the standard industrial solutions***





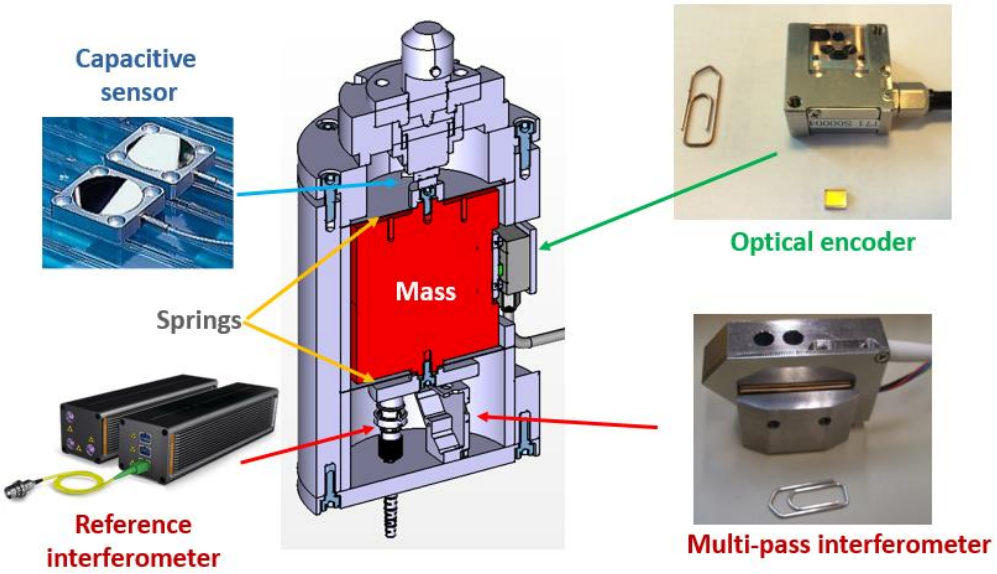
Example of usable PI (Biltz® B13W- vibration isolation rubber pad).

- **Poster session at IPAC17:** G. Balik et al, "Proof of concept of CLIC final focus quadrupoles stabilization", in Proceedings of International Particle Accelerator Conference (IPAC 2017), Copenhagen, Denmark.

Future prospects: :current sensor vibrations improvements

- ***Comparison of different technologies for the embedded sensitive part***

  - PACMAN : Particle Accelerator Components' Metrology and Alignment to the Nanometre scale (Marie Curie program at CERN)
  - Several labs and industries whose LAPP academic partner – SYMME co-director of the thesis
  - Use of the LAPP sensor with dedicated instrumentations

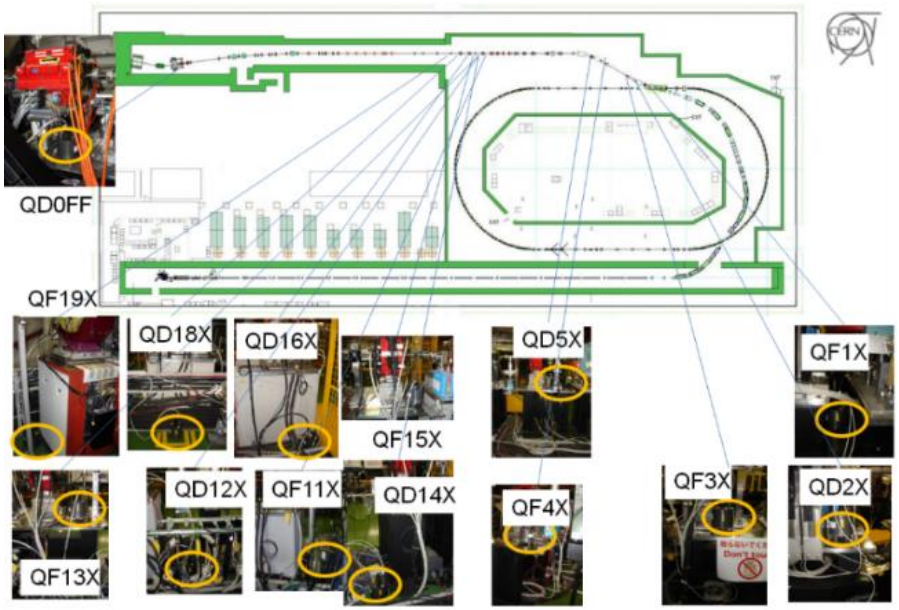


- Capacitive sensors : PI & Lion Precision
- Optical encoder : Magnescale
- Interferometer : Attocube & a developed one (INRiM (It) and ISI Brno (Cz))

- *P. Novotny et al, "What is the best displacement transducer for a seismic sensor?", IEEE Inertial Sensors and Systems 2017, Hawaï, USA.*

ATF2

- ***Involved in the assessment of the beam feed-forward control vs ground motion***



- 14 seismic sensors (Guralp 6T) are processing on site
- Collaboration with CERN, LAL et KEK
- Last campaign of measurements : May 2017

- *D. Bett et al, "Ground motion compensation using feed-forward control at ATF2, in Proceedings of International Particle Accelerator Conference (IPAC 2016), Busan, Korea.*

Conclusions about QD0 Stabilization

- Active control
  - A sensor dedicated to this vibrations control issue is developed
  - Sub-nanometer control is validated by demonstration on a small size prototype
- Future prospects
  - Improvements of the developed sensor (Comparison of different technologies for the embedded sensitive part)
  - Test of the whole process at a real scale (new collaboration is needed), with a MIMO control