LAPP

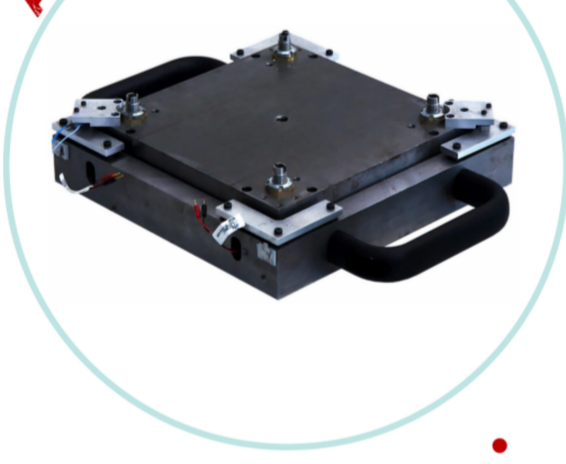
R&D IN VIBRATION CONTROL & MEASUREMENT

Large instruments for particles and astroparticles physics are requiring more and more stability regarding vibrations, with drastic specifications on devices becoming more and more complex.

In this context, LAPP has developed a strong expertise in the field of vibration control for many years.

Several aspects are now mastered, like sub-nanometric vibration control (R&D for future accelerators like CLIC), large structure vibration control (CTA telescope), simulation, sensor development and measurement

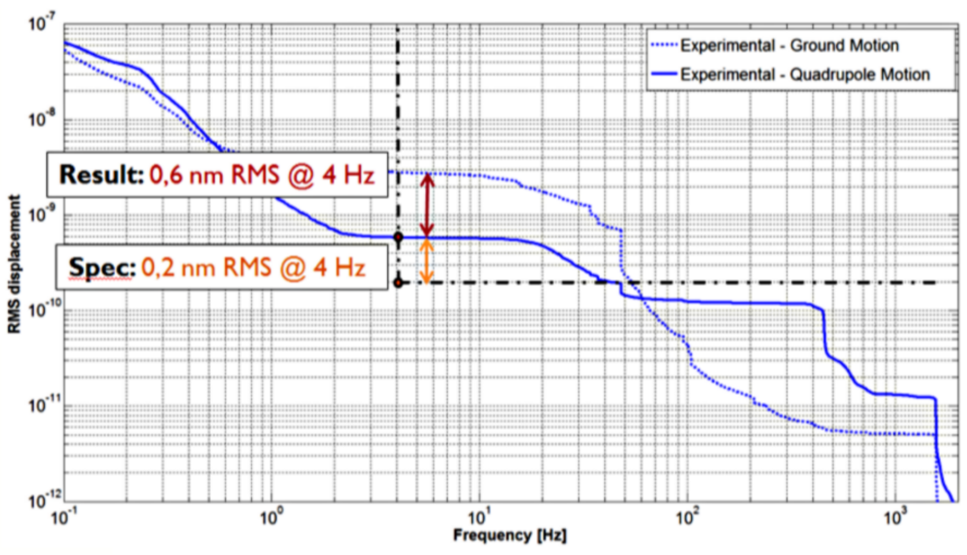
ACTIVE CONTROL FOOT



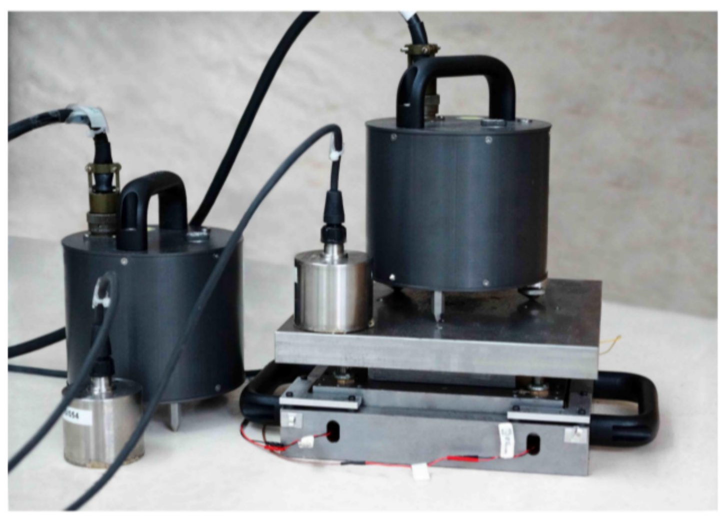
R&D for particle accelerators is performed at LAPP for future projects like CLIC. In order to reach very small beam sizes (~ 1nm), a sub-nanometric vibration control on focalisation magnets is required.

Therefore, the prototype of a complete system has been developed at LAPP, including sensors, processing loop and actuator (the active control foot).

- Technology based on four piezoelectric actuators.
- Active control performed : 0,6 nm @ 4 Hz
- Demonstrates the ability to set up such a system, including control, simulation, instrumentation and real-time at sub-nanometric scale.
- Control performed with several commercial sensors to cover the required bandwidth.



Ground motion vibration control results



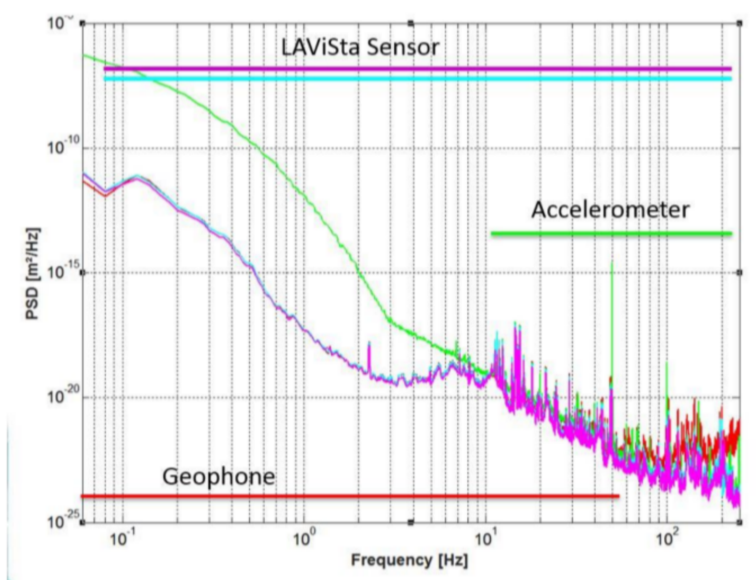
Device used to perform vibration control

LAVISTA VIBRATION SENSORS

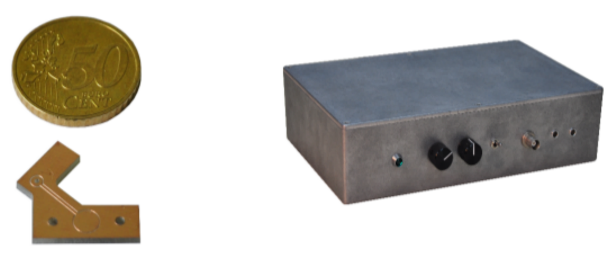
Several studies driven at LAPP (including Dr Bolzon's PhD thesis) have shown that sensors are the main limitation in the vibration control loop.

Suitable sensors have thus been developed to fit LAPP's application fields.

- Functional sensor prototype – reliable measurements
- The sensor, its element and its dedicated electronic is available at LAPP. Further mechanical, electronic and instrumental development are in progress
- Only one sensor used for the range [0.5 Hz : 250 Hz], where a geophone and an accelerometer were necessary for measurements in very quiet places and ultra-low vibrations.
- Patented solution (Nr FR 13 59336) for France and PCT extension. Outreach in progress with the SATT GIFT (Grenoble)
- Tested in real conditions in a CERN tunnel (24 hours measurement, in parallel with geophones and accelerometers).



Test of two LAViSta sensors at CERN, in parallel with a geophone and an accelerometer



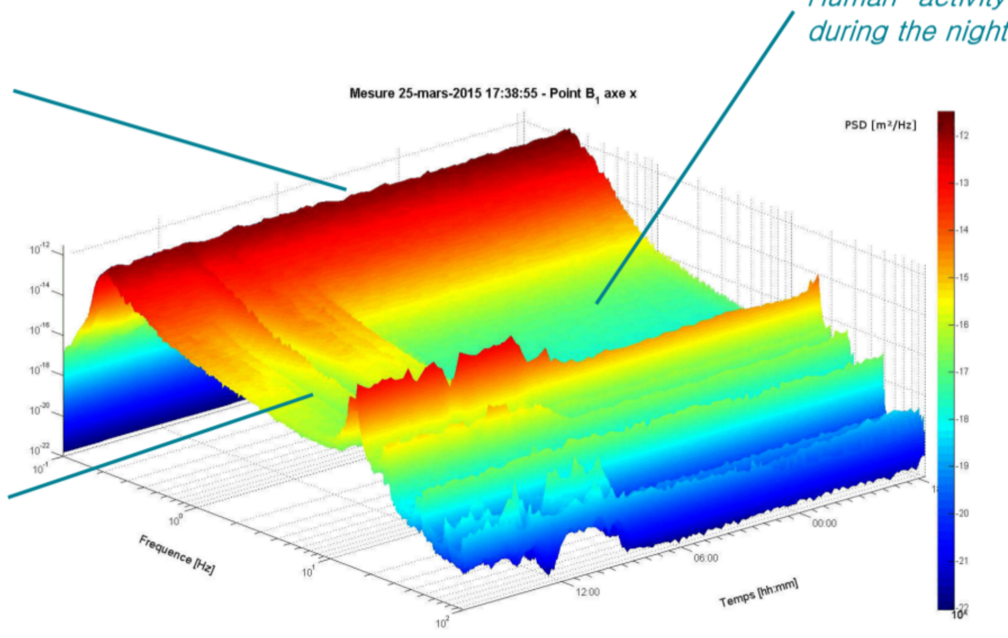
Sensitive element and dedicated electronic developed at LAPP for the sensors

MEASUREMENT KNOW HOW

in order to test LAPP sensors in real conditions and to promote research collaborations, LAPP provides occasionally measurement services.

This kind of campaign has been performed for different purposes :

- IRSN, Cadarache, measurements on a micro-beam line, for a new building behaviour evaluation.
- SuperB, Frascati (Italy), site evaluation before beam line construction.
- ATF2, Japan, measurements along the accelerator line.

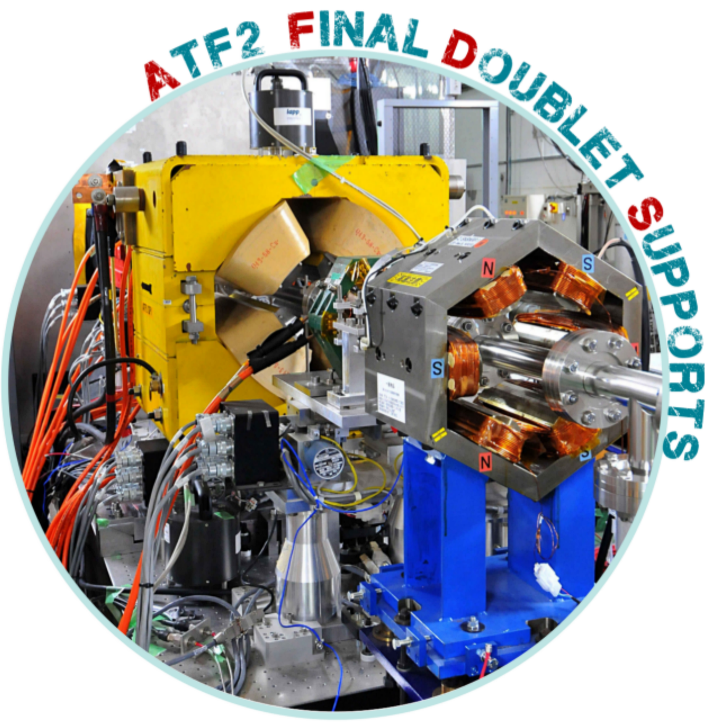


PSD of ground vibration over 24h

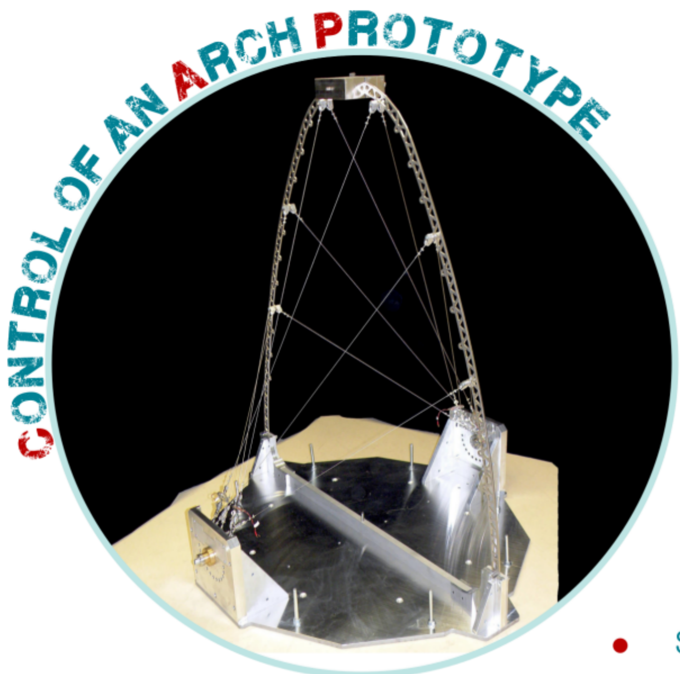
ATF2 FINAL DOUBLET SUPPORTS

As part of its collaboration with the particle accelerator demonstrator ATF2, in Japan, LAPP carried out the design and the realization of the supports of the final focalisation magnets.

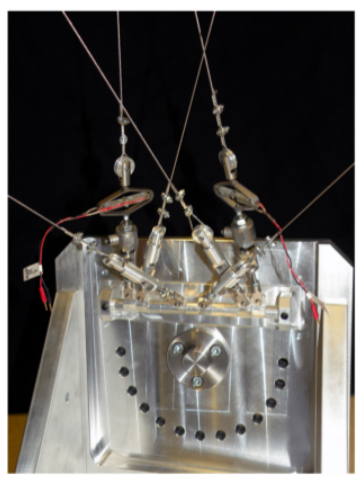
Measurements performed on the beam line showed the efficiency of the system to keep relative displacement between target and magnets in the specifications. So the beam size of 44 nm has been reached.



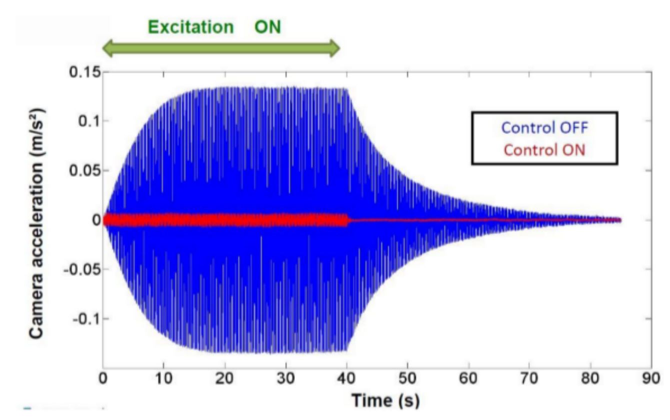
CONTROL OF AN ARCH PROTOTYPE



- LAPP realized studies for the camera vibration control of the CTA telescope.
- Dummy camera is placed at the top of the prototype arch, and its vibrations are controlled with piezoelectric actuators and wires.
- Thanks to the vibration control system, the acceleration experienced by the camera is highly reduced (see the graph below).
- Several kinds of vibrations, like wind, have been tested with success.



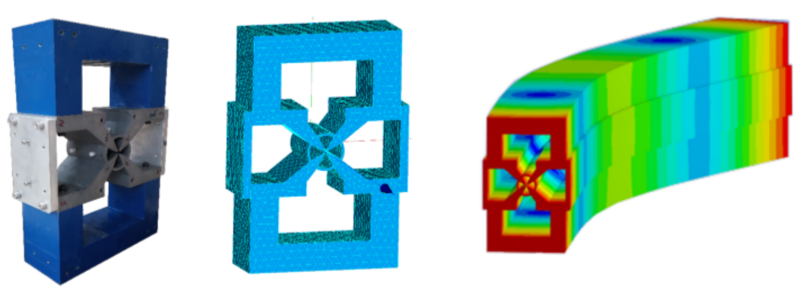
Piezoelectric actuators



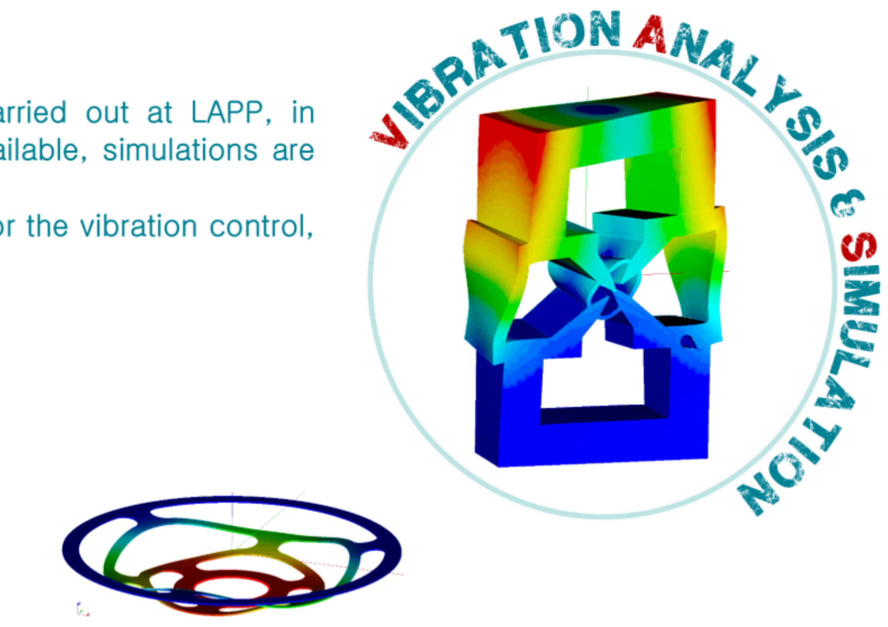
Acceleration experienced by the camera, with and without vibration control

VIBRATION ANALYSIS & SIMULATION

Different kinds of vibration simulations are frequently carried out at LAPP, in collaboration with SYMME. If the material is physically available, simulations are also compared with the vibration measurements.
The numerical model is then included in the control loop for the vibration control, and is also used as a predictive tool for design.



Vibration analysis on a existing part of magnet, compared with simulation, then simulation of the complete magnet in vibration



Simulation of a part of the vibration sensor, to validate the design. Displacements, eigenfrequencies, transfer function, and response to ground motion are calculated and compared to real sensor.

Main publications :

- G. Balik (LAPP), B. Caron (SYMME), D. Schulte, J. Snuverink, J. Pfingstner (CERN), Integrated simulation of ground motion mitigation, techniques for the future compact linear collider (CLIC), Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 700 (2013) 163 - 170.
- G. Balik, J. Allibe, J.P. Baud, G. Deleglise, A. Jérémie, S. Vilalte (LAPP), B. Caron, A. Badel, R. Le Breton (SYMME), Sub-nanometer active seismic isolator control, Journal of Intelligent Material Systems and Structures 24 (15) (2013) 1785-1795.
- B. Caron, G. Balik, L. Brunetti, A. Jérémie, "Vibration control of the beam of the future linear collider", Control Engineering Practice 20 (2012) 236
- R. Le Breton, A. Badel, B. Caron, J. Lottin (SYMME) G. Deleglise, J. Allibe, G. Balik, A. Jeremie, S. Vilalte (LAPP), Nanometer scale active ground motion isolator, Sensors and Actuators A: Physical, 2013.
- Mitigation of ground motion effects in linear accelerators via feed-forward control, by J.Pfingstner et al.: Physical Review Special Topics - Accelerators and Beams 17, 122801 (2014)
- ...
  Regular presentation and publications in main physical and mecatronics conferences :
  PAC09, IWLC10, IPAC10, PAC11, IPAC11, LCWS11, LCWS12, ECFA13, LCWS13, LINAC14, Mecatronics10, ICINCO11.

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