QD0 stabilization

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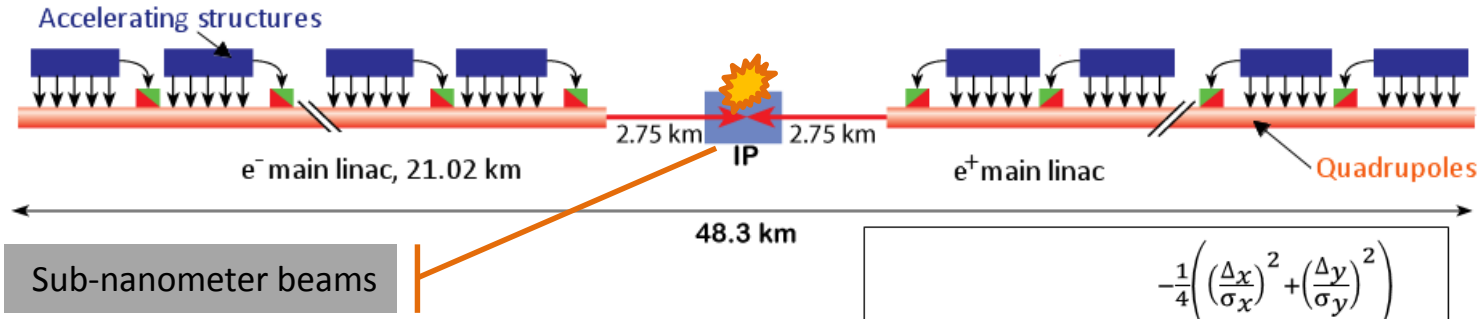
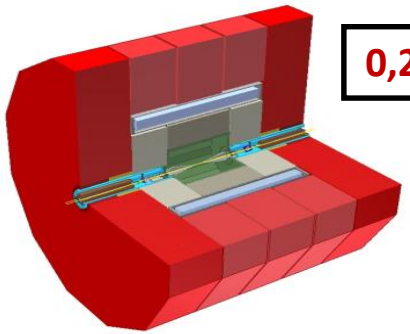
CLIC Challenge vs QD0 stabilization

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

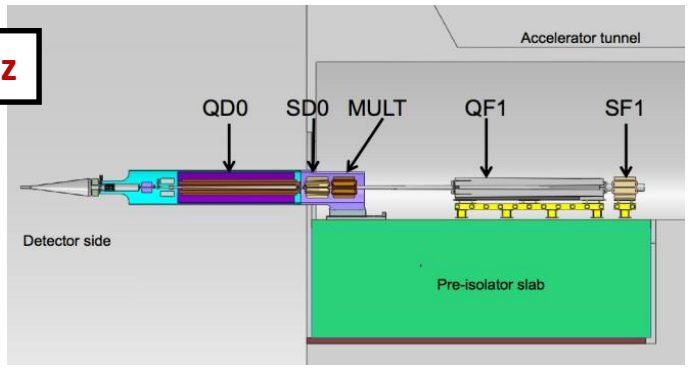


$$L(\sigma_{x,y}, \Delta_{x,y}) \sim \frac{e^{-\frac{1}{4}\left(\left(\frac{\Delta x}{\sigma_x}\right)^2+\left(\frac{\Delta y}{\sigma_y}\right)^2\right)}}{\sigma_x \sigma_y}$$

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

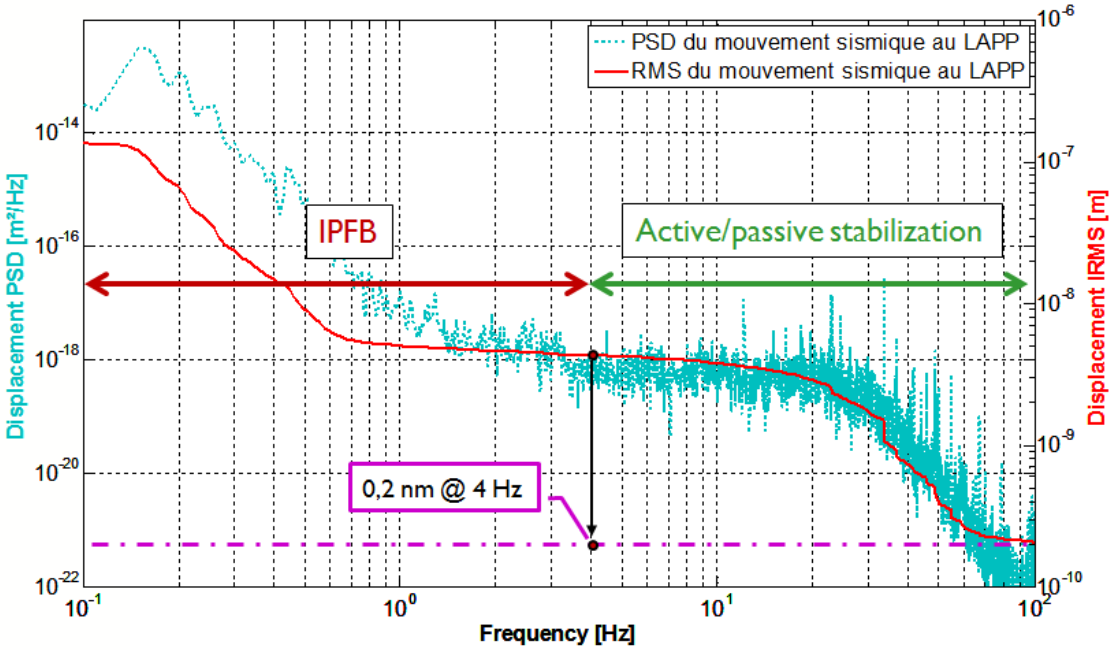


0,2 nm RMS @ 0,1Hz



Introduction

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

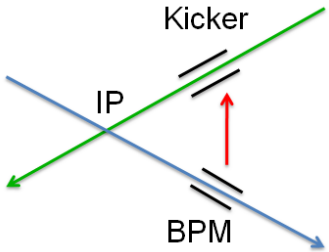


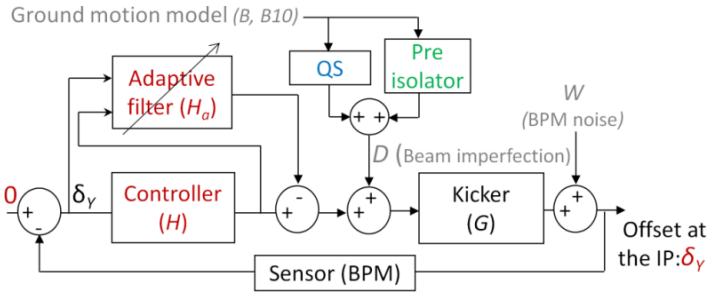
➢ At the IP (mechanical + beam feedback), we aim at **0,2nm at 0,1Hz**

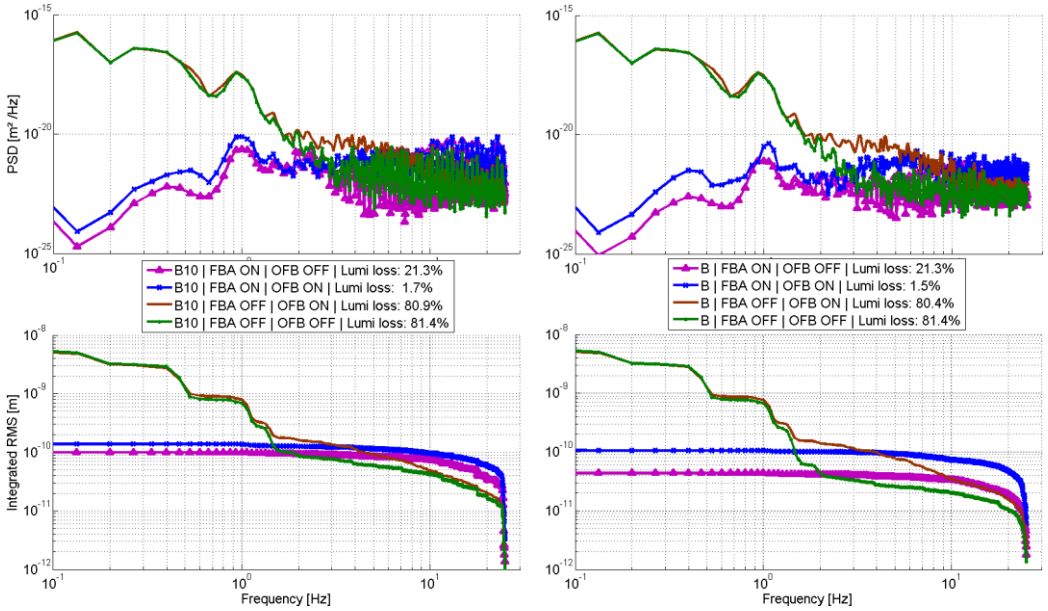
- **IP Beam based feedback : already developed in collaboration with CERN since 2010**
- **Mechanical stabilization has to be achieved**

IP feedback

- ***Beam trajectory control : simulation under Placet***





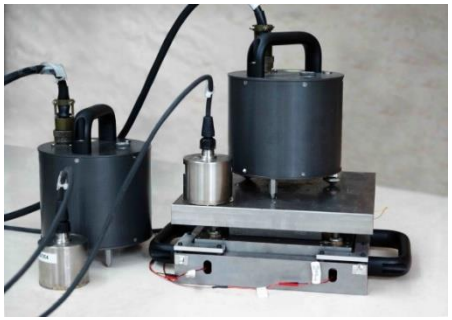


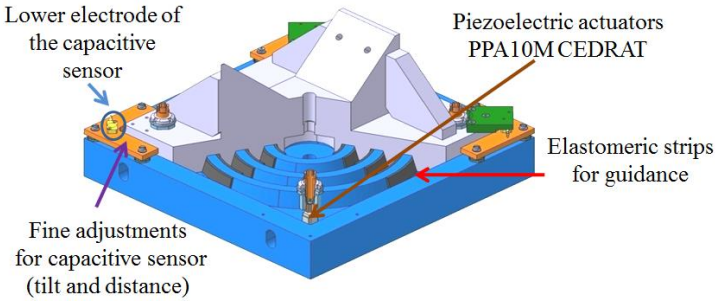
- *Luminosity vs control ON or OFF and vs model of seismic motion (deal under Placet)*

- 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

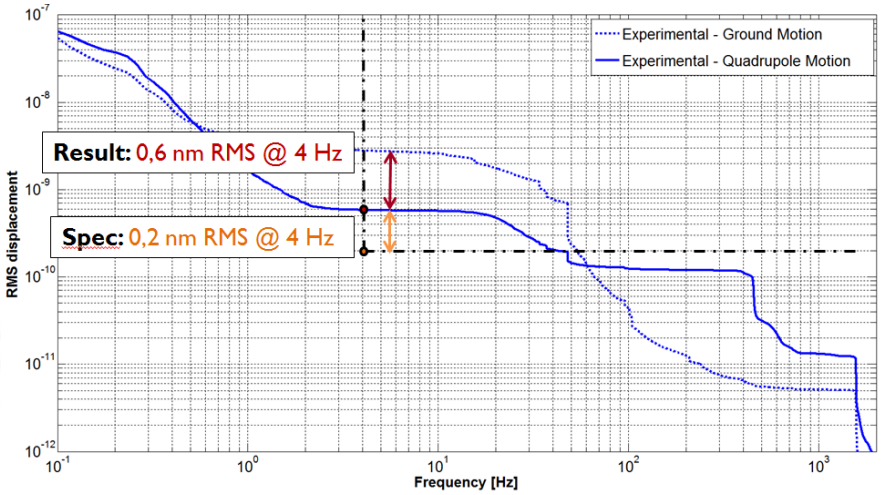
Active control : demonstration

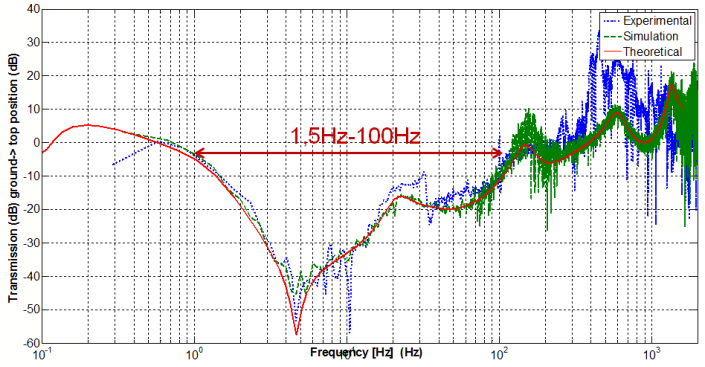
- ***Prototype of active control system :***





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



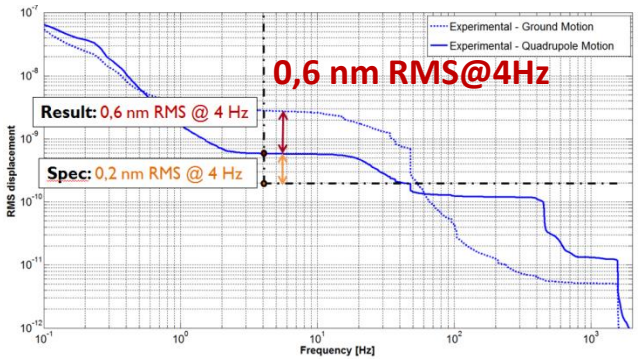


Balik et al, "Active control of a subnanometer isolator", JIMMSS.

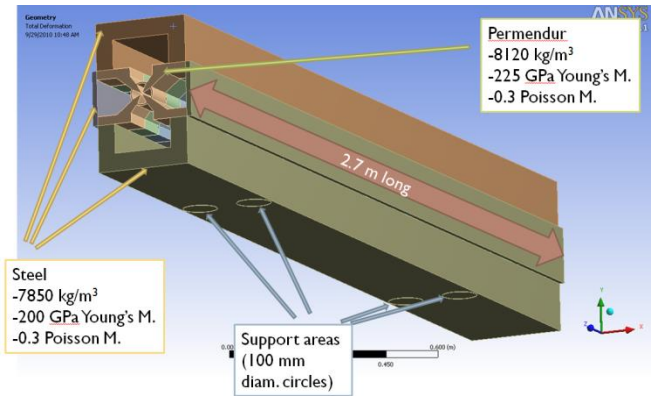
➢ Main limitation : SENSOR (simulation and experiment).

Transfer on a real scale

- ***Demonstration active table to QD0 active control ?***



One active foot

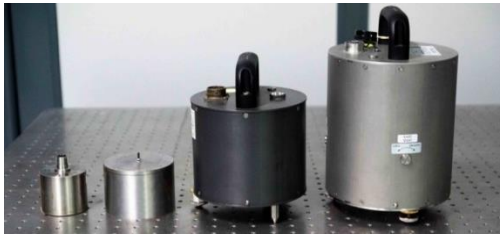


Several active feet

- ***Mecatronics challenges :***
  - Sensors
  - Actuators
  - Structure : QD0 Magnet
  - Integration: control, data processing, real time…

Sensors : LAViSta prototypes

- Successive developed prototypes since 2011 :

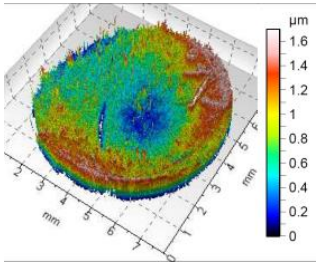


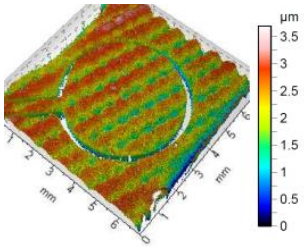
- Mechanical system with capacitive differential measurement
- Exploiting mechanical amplification at low frequency

  - Validation of the tilt, temperature drift, repeatability
  - Spurious frequencies are managed
  - R&D: a pneumatic approach is in progress

Sensors : Developments & tests

- ***Current developments:***
  - Development of the sensitive part



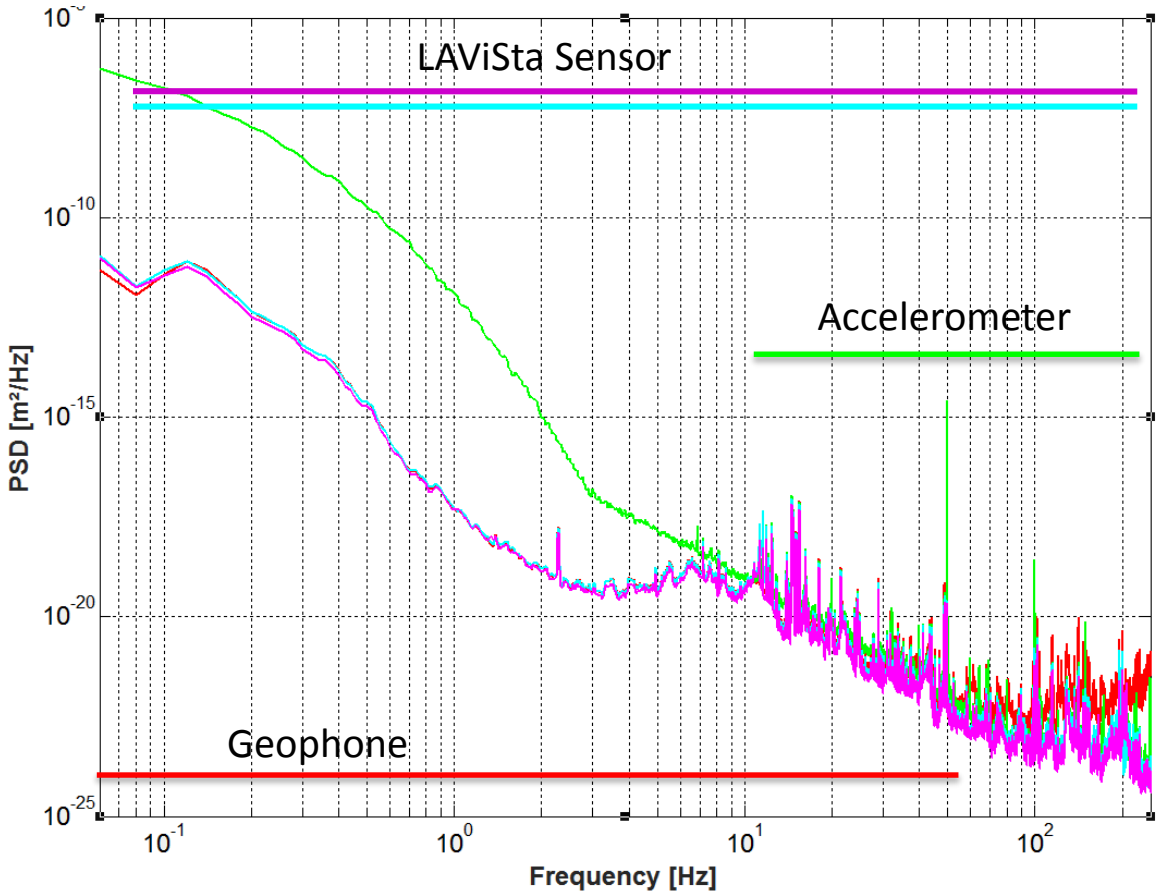


  - Development of the data processing
  - Transfer function

- ***Tests on site:***
  - At Cern (22-23 January 2015 at ISR building)
  - On a micro beam experiment in March
- ***Outreach aspects***

Sensors : Measurements on site

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



Geophone (Güralp 3-ESP)

Low frequencies

Accelerometer (Wilcoxon 731A)

Mid-High frequencies

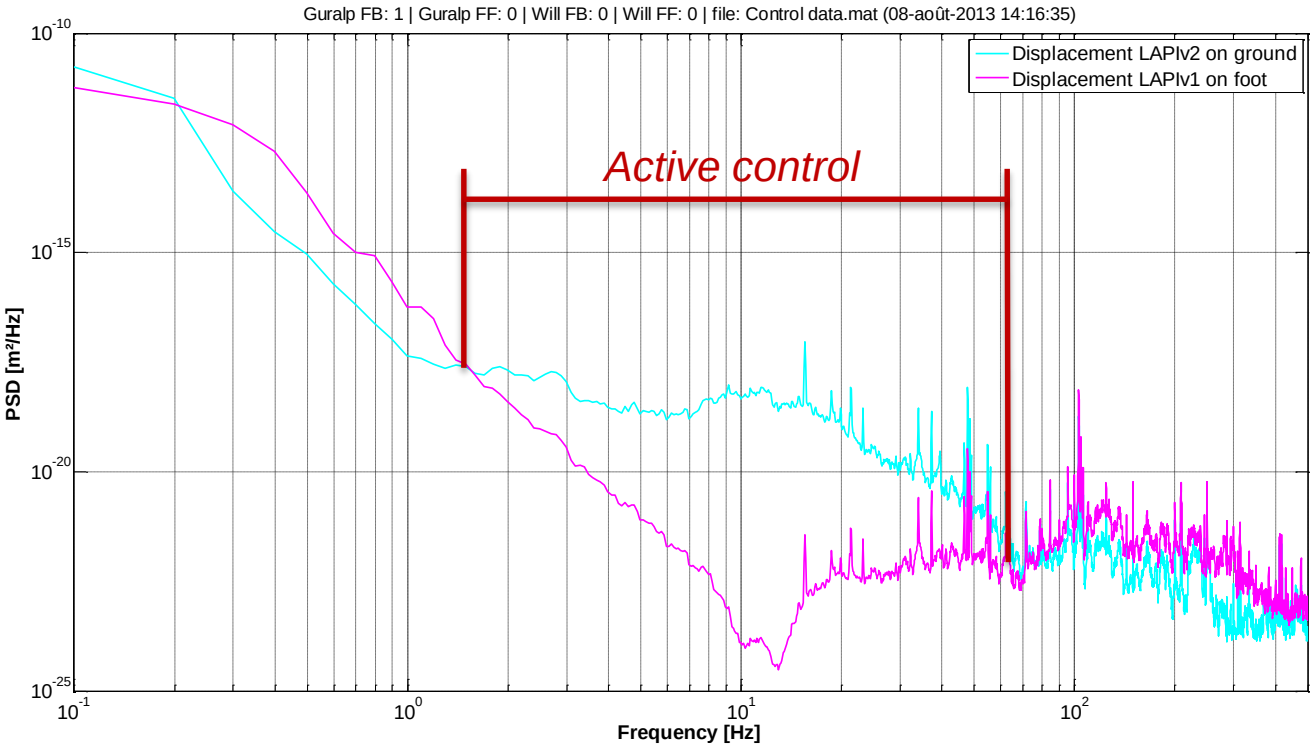
LAViSta sensor (x2)

Large bandwidth

➢ Approach validated → Patent n° FR 13 59336 in progress.

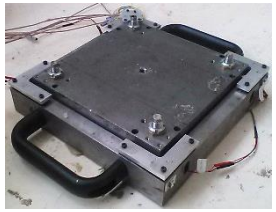
Sensors : Active control

- ***Active control with LAViSta sensor (First tests : 1,5Hz - 65Hz)***



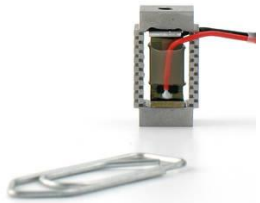
LAViSta sensor

LAViSta Active Table

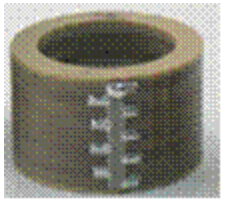


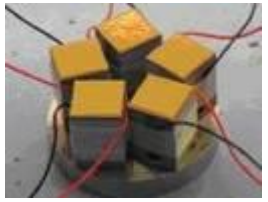
Actuators

- ***No commercial solution for dynamics, resolution, load, stiffness…***
  - Two challenging ways : internal development or industrial partnership…
- ***Industrial solution : PZT actuator***
  - Foreseen collaboration: SYMME, G2Elab, CEDRAT Technologies, SIREPE and LAPP
  - ANR (French agency) submitted (for 3 years). Pre-proposal decision in February…



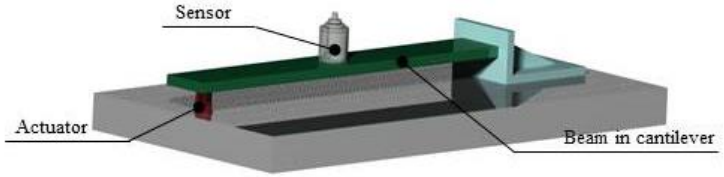
Small size PZT actuator

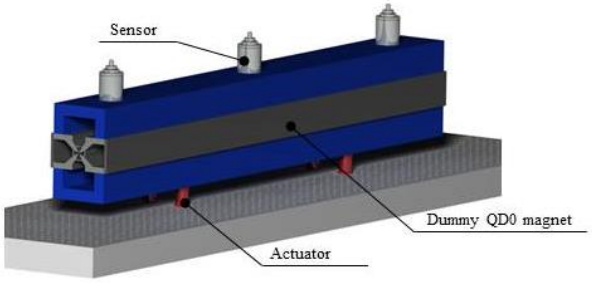




Example of a large actuator

- Specifications and tests vs ANR



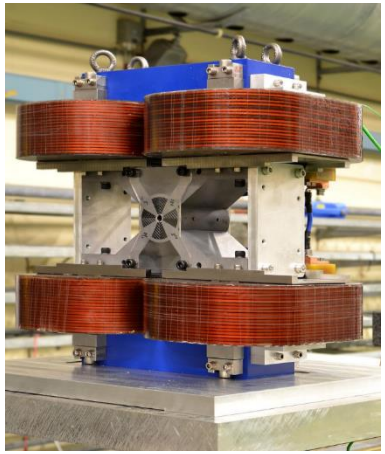


Conceptual views of the future tests benches

- The ANR decision is a strategic step for the future of the project…

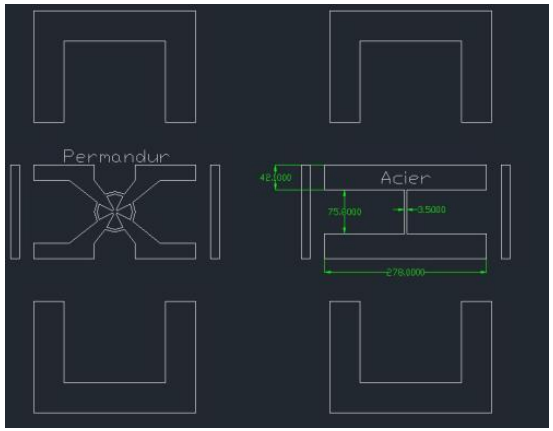
Mechanical structure : Tests & Simulations on short QD0 for dummy QD0

- ***Dummy QD0 magnet prototype :***



- Design and modeling of the large prototype
- Modal analysis of the short QD0 to confirm the simulation results (without coils).

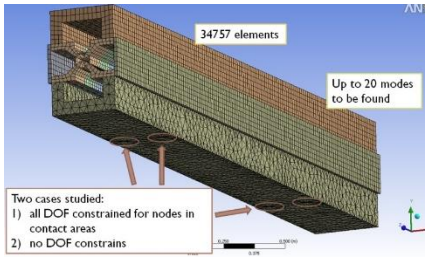
- <u>Objectives of the prototype</u> :
  - Dynamics behavior (eigenfrequencies, damping…)
  - Size
  - Geometry
  - Mass

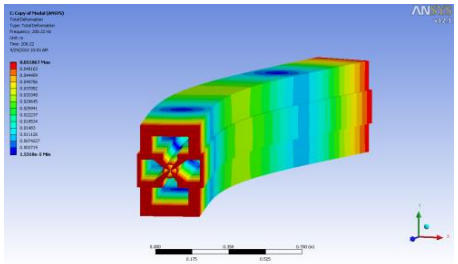


➢ *Most elementary as possible for machining, assembling, cost, delays…*

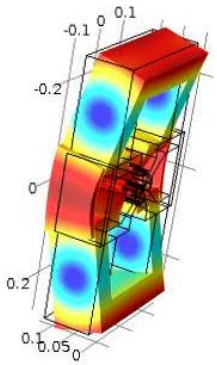
Mechanical structure : Simulation

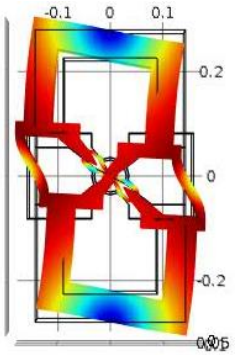
- ***Simulation studies of QD0 :***
  - Initial study performed by the team of M. Modena

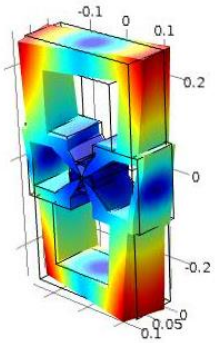




  - Short QD0 study :
    - Boundary conditions : Clamped and Free
    - Modeling of contacts, screws pre-stress…

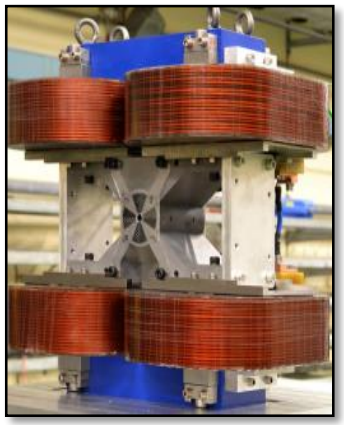
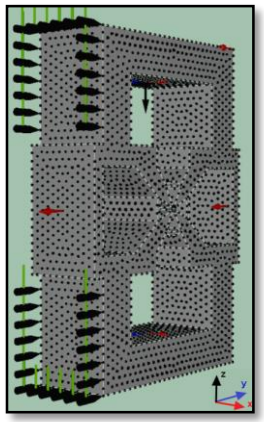
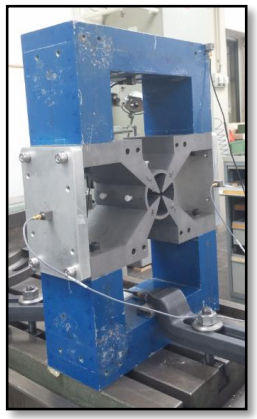
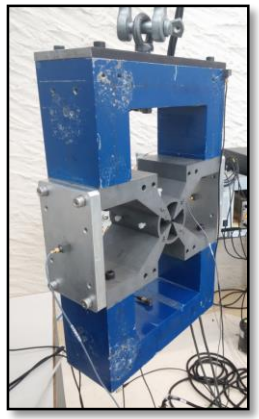
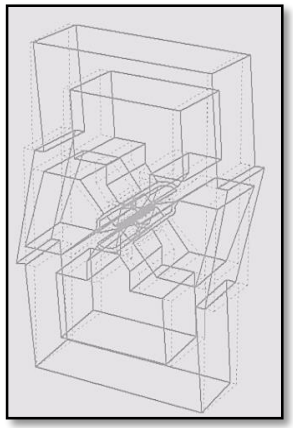






Mechanical structure : Tests

- ***Objectives:***
  - Modal analysis of short QD0 in order to adapt the simulation of real QD0
  - Design and simulation of a dummy QD0 to machine a new test bench
  - Integration of the PZT actuators in the simulation to develop the control laws

Comparison experimental tests and theoretical results

- ***Clamped magnet:***

Modes	Pulse + Me'scope	*DSpace + Matlab*	FE Analysis
1st x flexion	100	*100*	169
1st y flexion	200	*200*	227
1st torsion	370	*350*	454
2nd x flexion	680	*640*	949
2nd y flexion	1000	*1000*	1163

- ***Free - free magnet:***

Modes	Pulse + Me'scope	*DSpace + Matlab*	FE Analysis
1st x flexion	520	*540*	
1st y flexion	600	*580*	675
1st torsion	660	*640*	655
2nd x flexion	760	*740*	686
2nd y flexion	1400		1363

- **Deformed shape are fitting**
- **Problem of boundary conditions :** clamping and structure rigidity
  - Technical report available : *LAPP-Tech-2015-01*
  - Confident for the large QD0 magnet and prototype vs past studies (ex: magnet, telescope, support…)

Conclusions about QD0 Stabilization

- Active control
  - Sub-nanometer control is validated by demonstration
- Sensors :
  - Efficient prototypes already available
  - Development still in progress
- QD0 structure studies
  - Actuator : waiting for ANR decision to start development and collaboration
  - MIMO control under simulation
  - Modal studies completed on short QD0 (report available)
    - Dummy QD0 structure under investigation