Optimization of the final focus stabilization for CLIC

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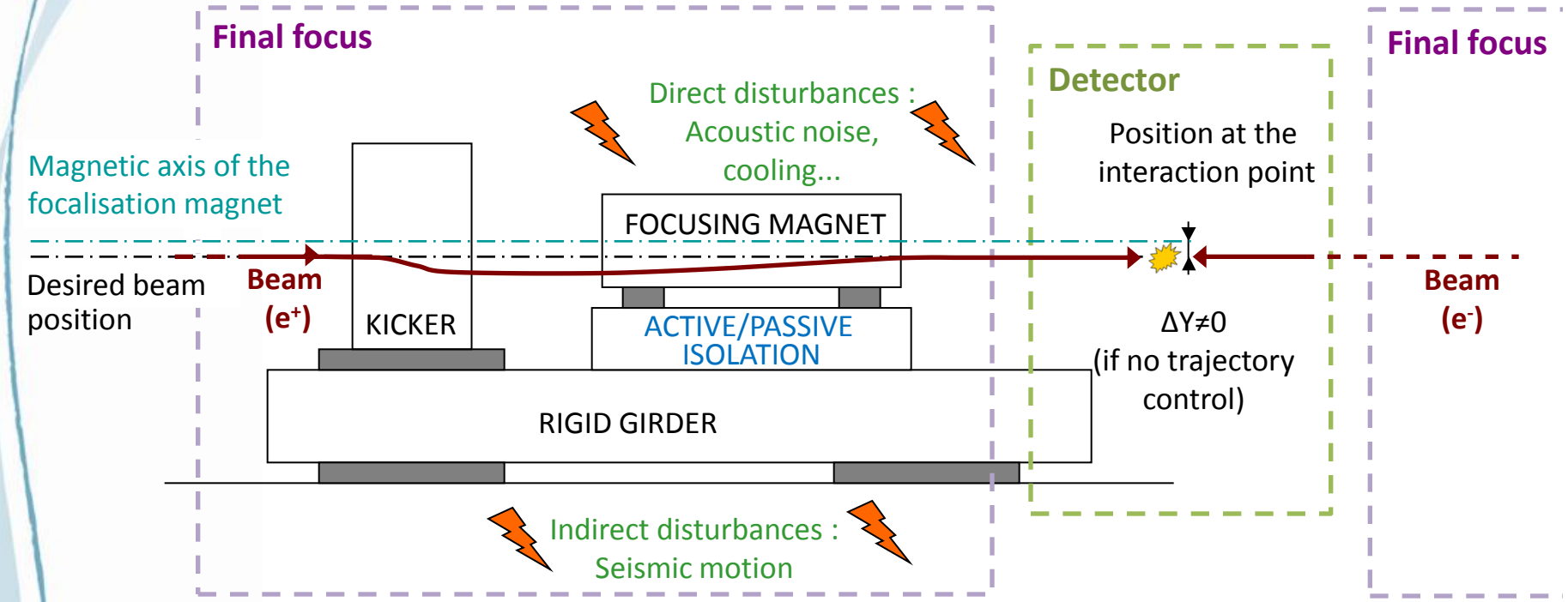
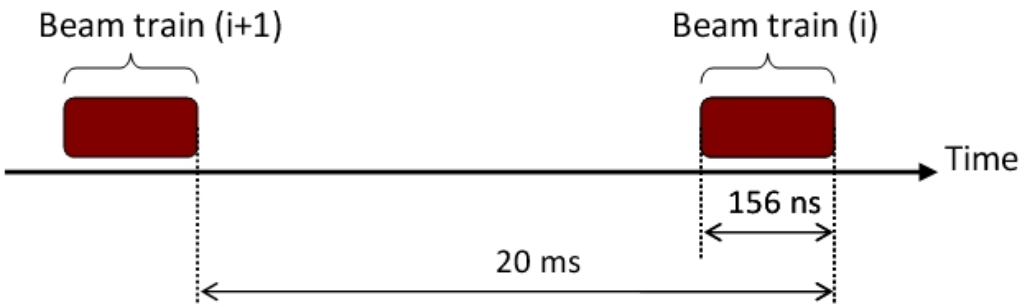
Final focus stabilization

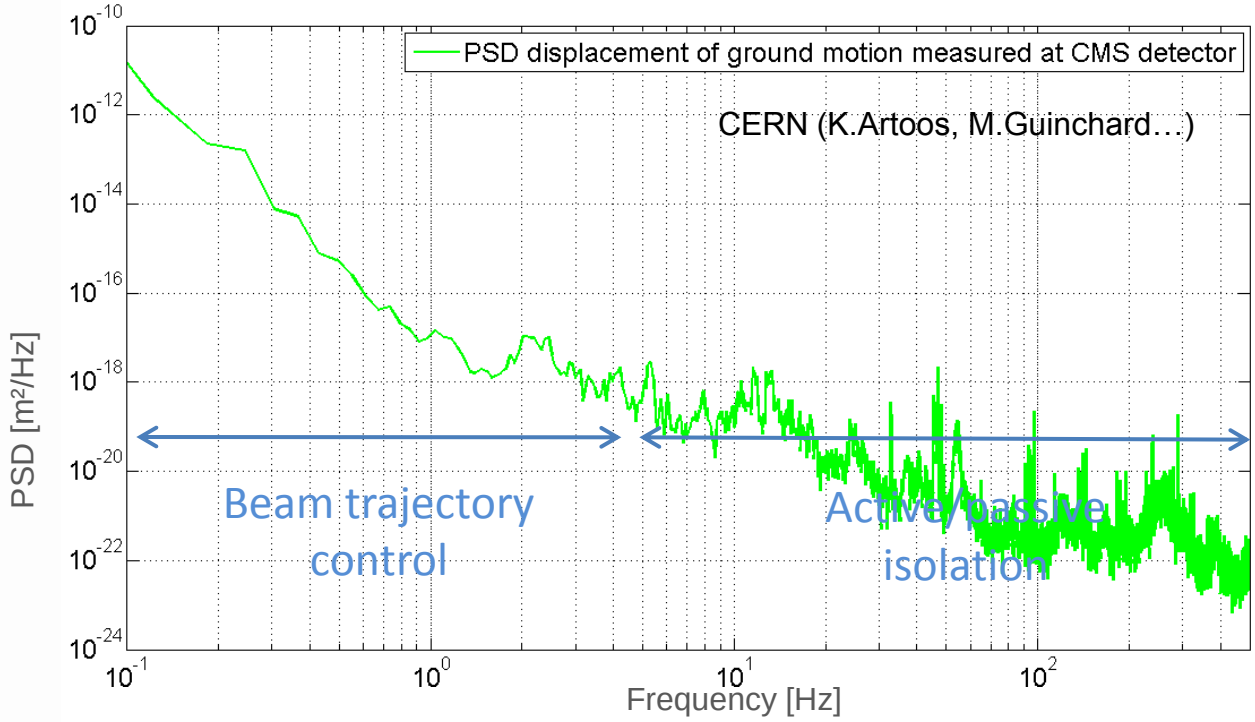




Repetition rate of the beam:
50 Hz

Specification:
Displacement of the beam at the IP < 0.1nm integrated RMS @ 0Hz

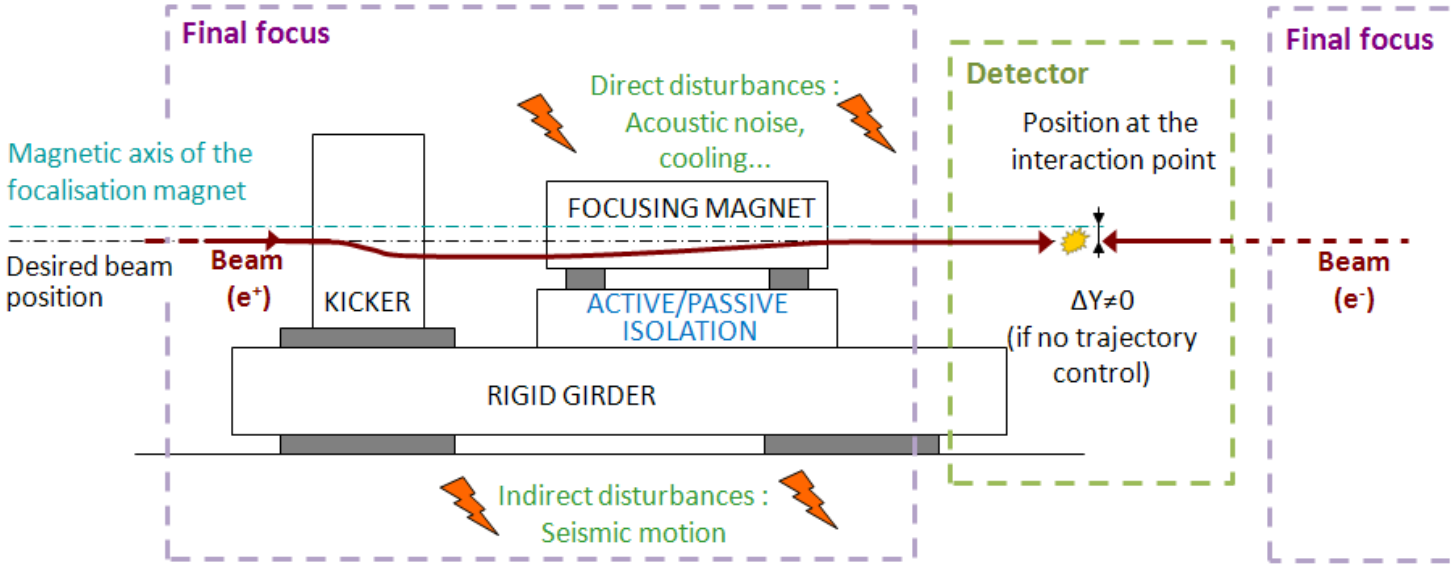
Typical ground motion measured at CMS

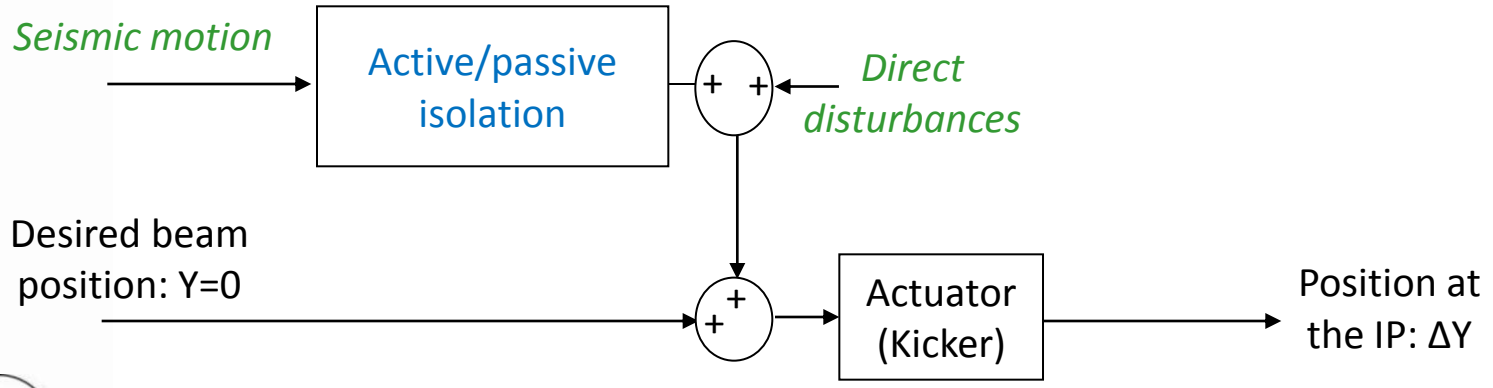


Beam trajectory control limited by the repetition rate of the beam

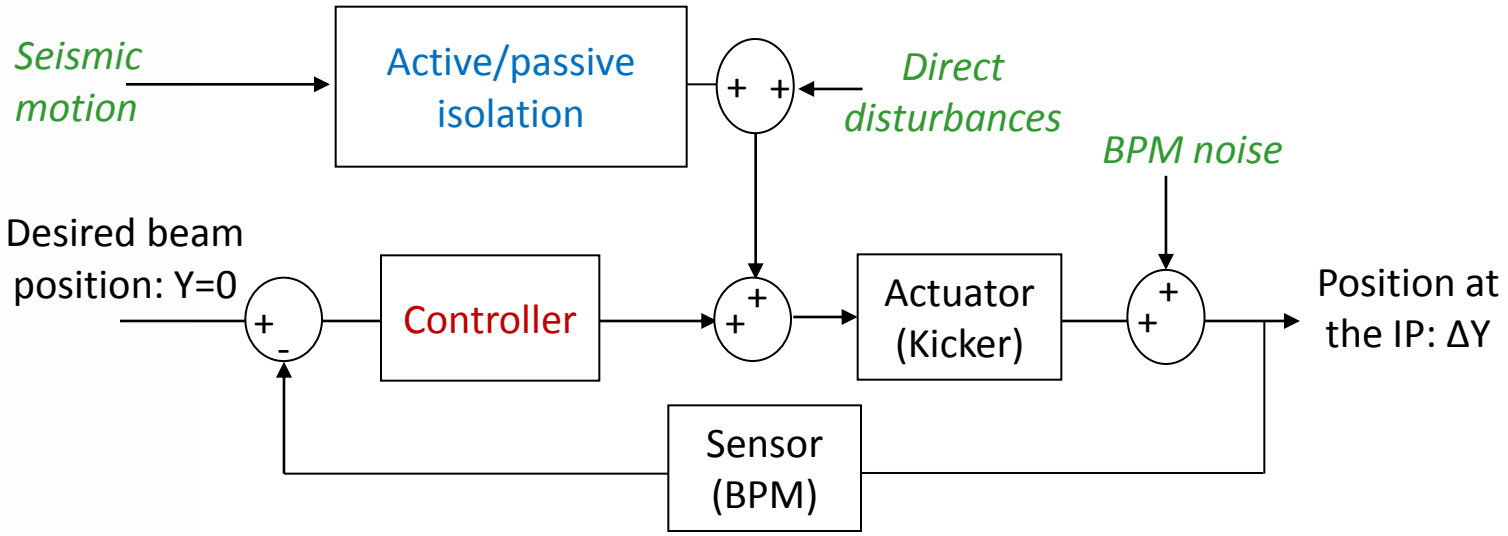
Ground motion integrated RMS already between a few nm to dozens of nm at 5 Hz

Mechanical scheme and control point of view





Feedback scheme

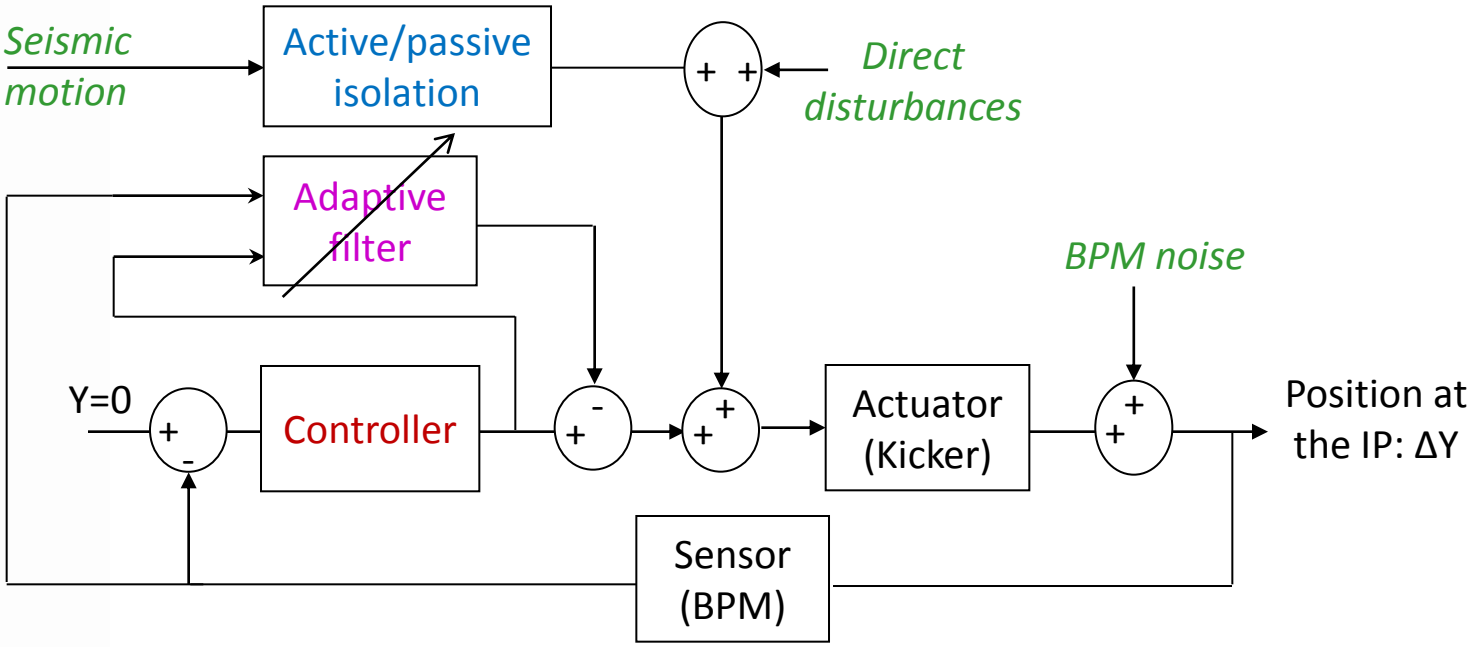


Controller optimized to minimize the PSD of displacement of the beam (ΔY) in function of the disturbance *seismic motion*

- The results of the optimization depend on the considered seismic motion and on the active passive isolation.
- Efficiency of the feedback scheme: 0 Hz to [4 – 5]Hz

  (limited by the repetition rate of the beam: 50Hz)
- It is needed to improve the efficiency of the control

Feedback + Adaptive scheme

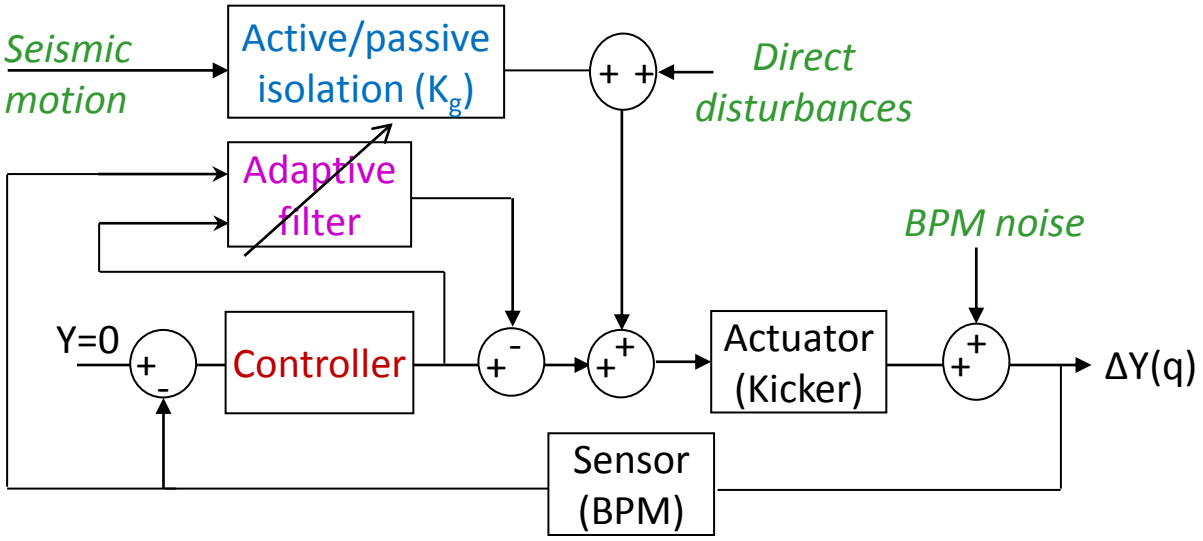


- Adaptive filter reconstruct and cancel the disturbance

  Efficiency of the control greatly increased (in the same range: 0 Hz to [4 – 5]Hz)
- Beam motion still at a detrimental level at 5Hz
- Specification of the future active/passive isolation

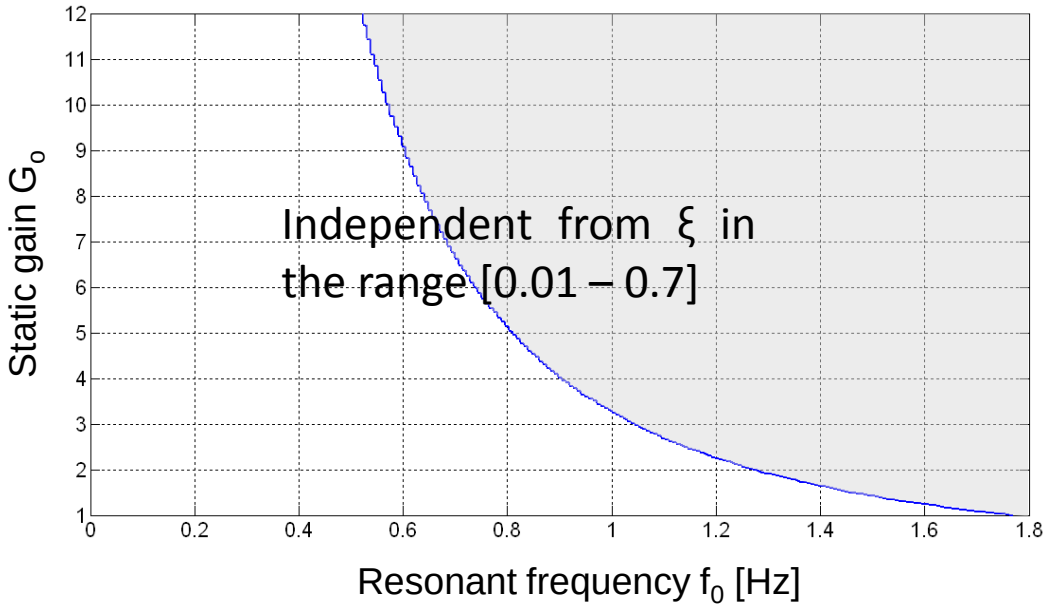
Pattern of a global active/passive isolation

Determination of the pattern of the global Active/passive isolation (K_g)

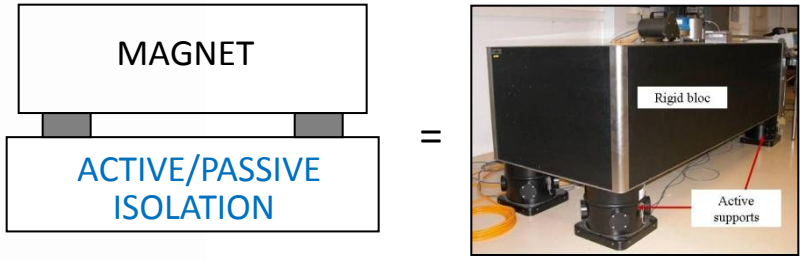


Example if we consider K_g as a second order low pass filter:

$$K_g(s) = \frac{G_0}{1 + \frac{2\xi}{\omega_0} s + \frac{1}{\omega_0^2} s^2}$$

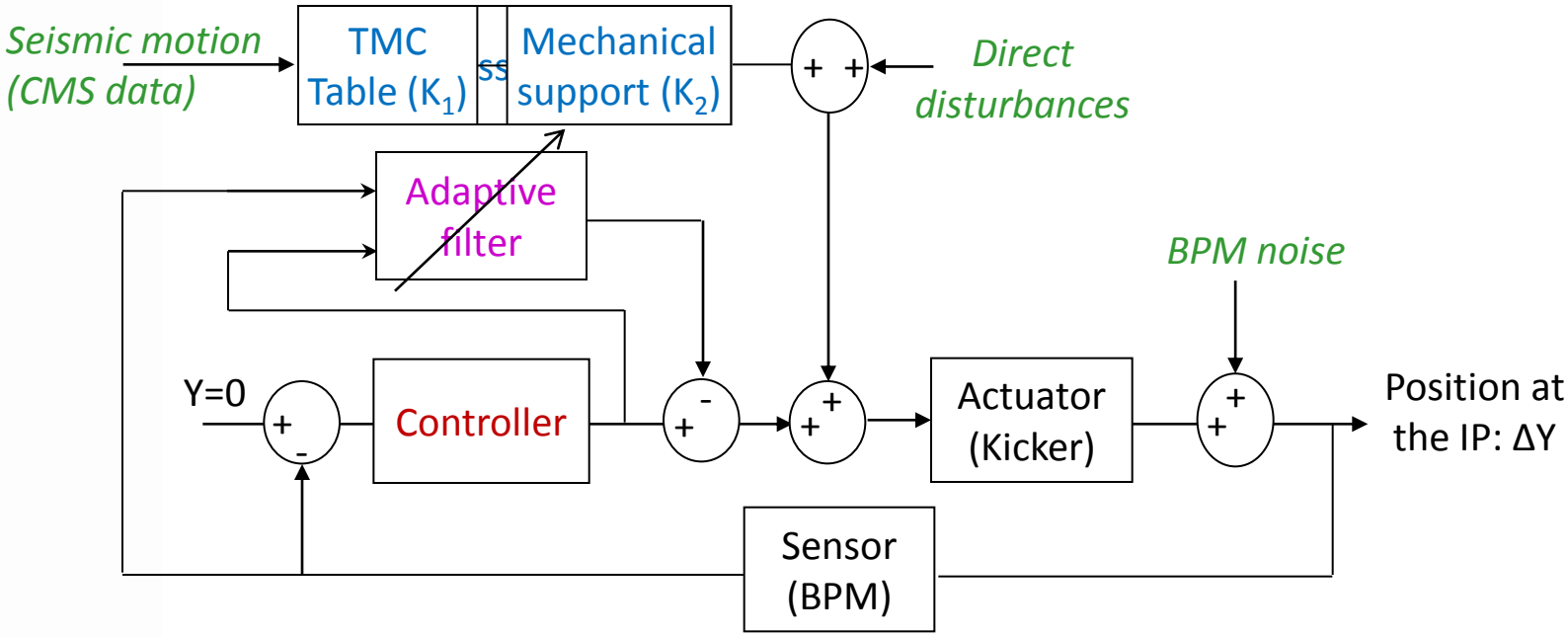


Feasibility demonstration with industrial products

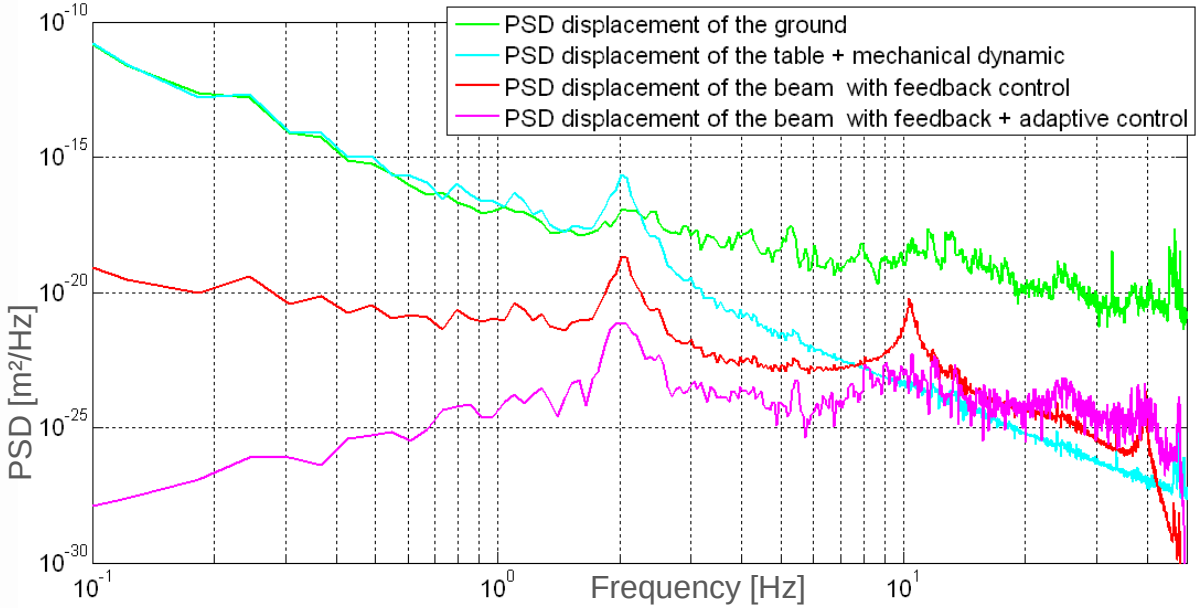


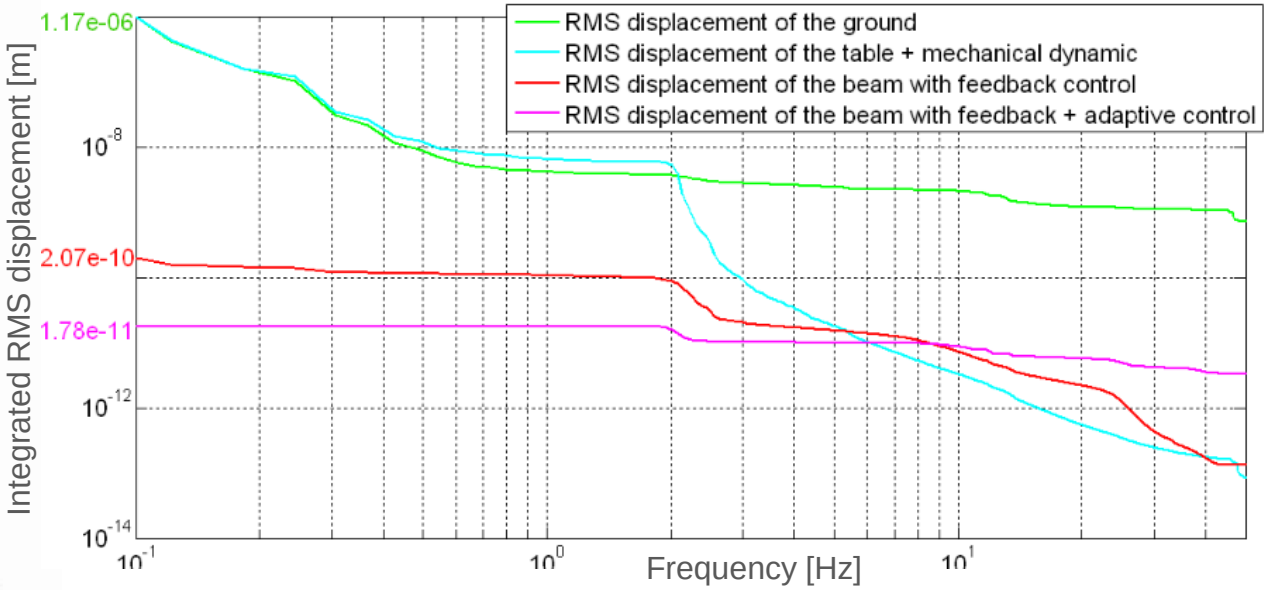
TMC table (K_1)

Mechanical support (K_2) { f_0 = 2Hz, ξ = 0.01



Results


PSD displacement of the ground
PSD displacement of the table + mechanical dynamic
PSD displacement of the beam with feedback control
PSD displacement of the beam with feedback + adaptive control
PSD [m²/Hz]
Frequency [Hz]


RMS displacement of the ground
RMS displacement of the table + mechanical dynamic
RMS displacement of the beam with feedback control
RMS displacement of the beam with feedback + adaptive control
Integrated RMS displacement [m]
1.17e-06
2.07e-10
1.78e-11
Frequency [Hz]

Robustness (Mechanical support)

Integrated RMS displacement = f(ξ, f0)

- Controller optimized for the PSD of the ground motion filtered by the TMC table + Mechanical support K_2

$$K_2(s) = \frac{1}{1 + \frac{2\xi}{\omega_0} s + \frac{1}{\omega_0^2} s^2}$$

ξ= 0.01

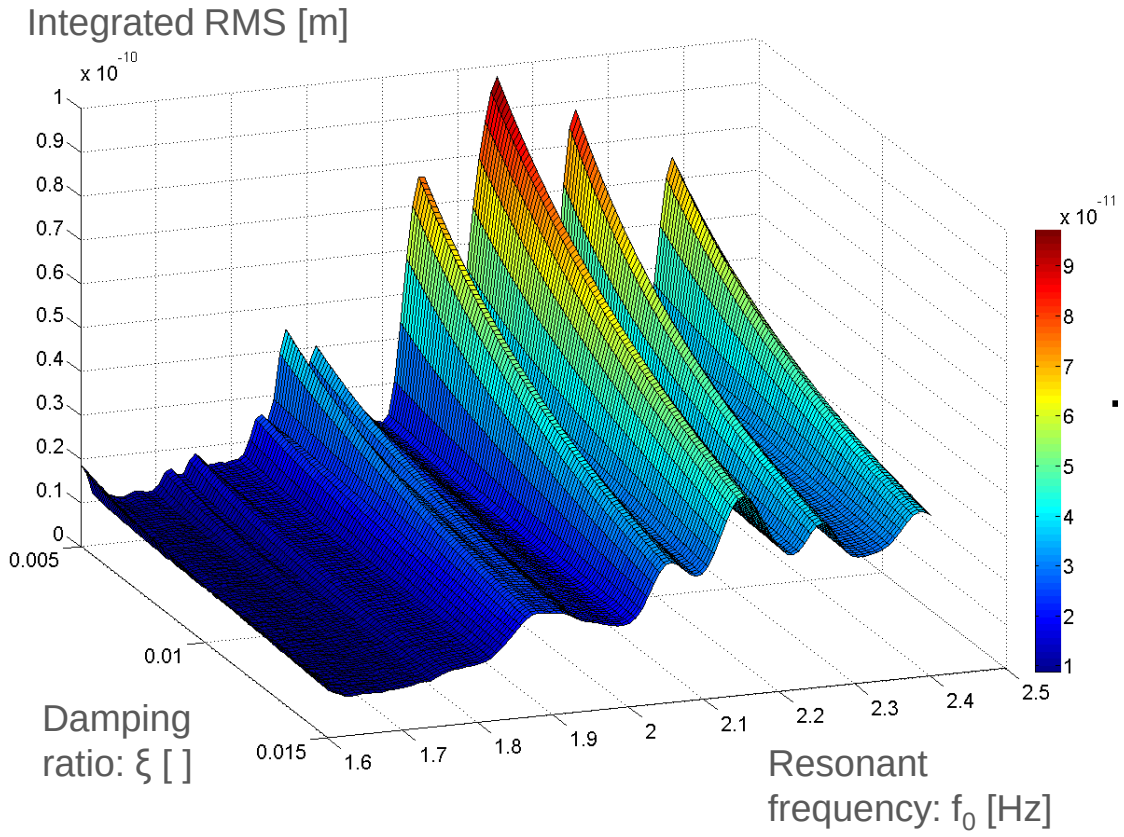
f_0 = 2 Hz

$f_0 = f_0 \pm 10\%$

$\xi = \xi \pm 50\%$

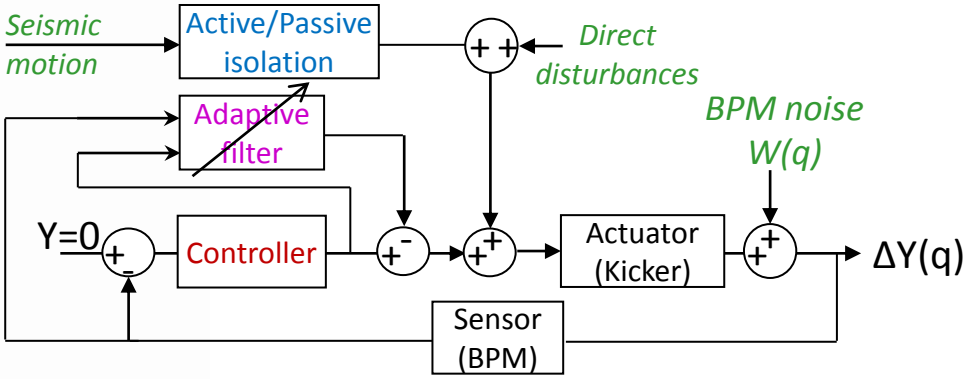
- The worst case:
  f_0 = 2.2 Hz
  ξ = 0.005

Integrated RMS displacement of the beam 0.1nm @ 0.1Hz



Robustness (BPM noise)

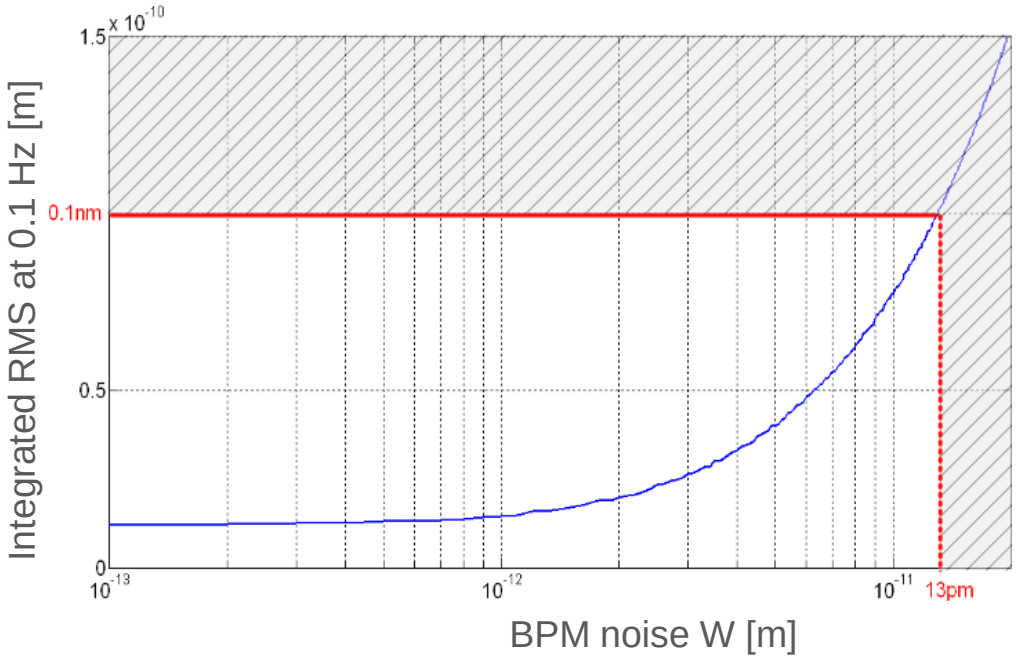
Integrated RMS displacement = f(W)



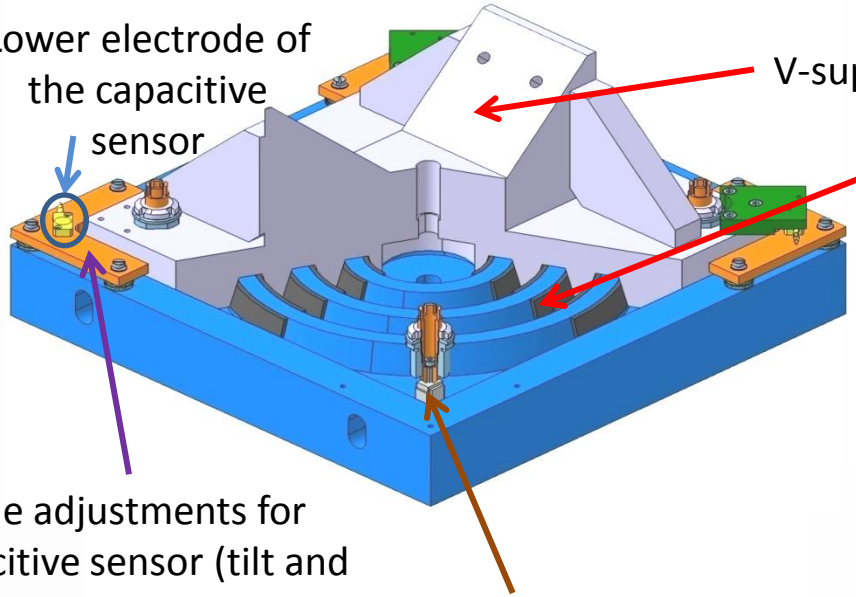
- W: white noise added to the measured displacement

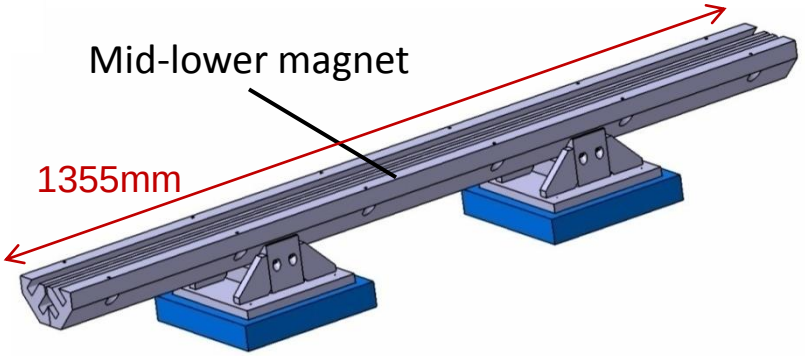
BPM's noise has to be < 13 pm integrated RMS @ 0.1 Hz

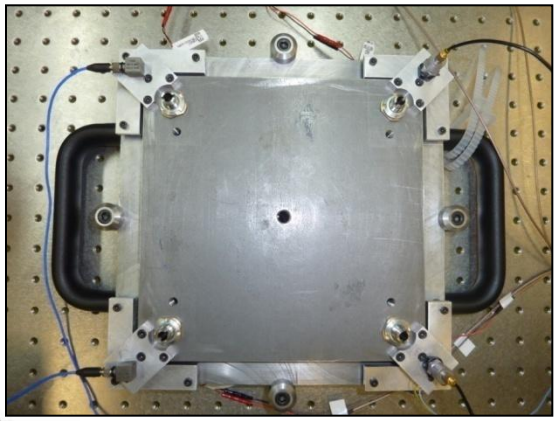
The BPM is a post collision BPM: Amplification of 10^5



Example with the solution being developed at LAPP







Mechanical support for magnet
(A. Badel, J-P. Baud, R. Le Breton, G. Deleglise, A. Jérémie, J. Lottin, L. Pacquet)

Conclusions

- **Feedback + Adaptive control:**
  - Feasibility demonstration of the beam stabilization proposed
  - New specification of the active/passive isolation

- **Future prospects :**
  - Implementation of the controller under placet