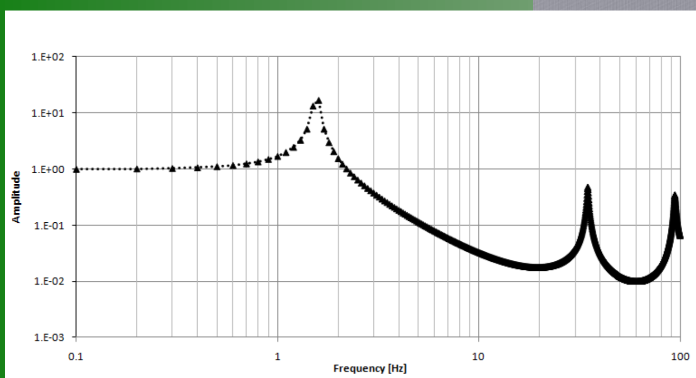
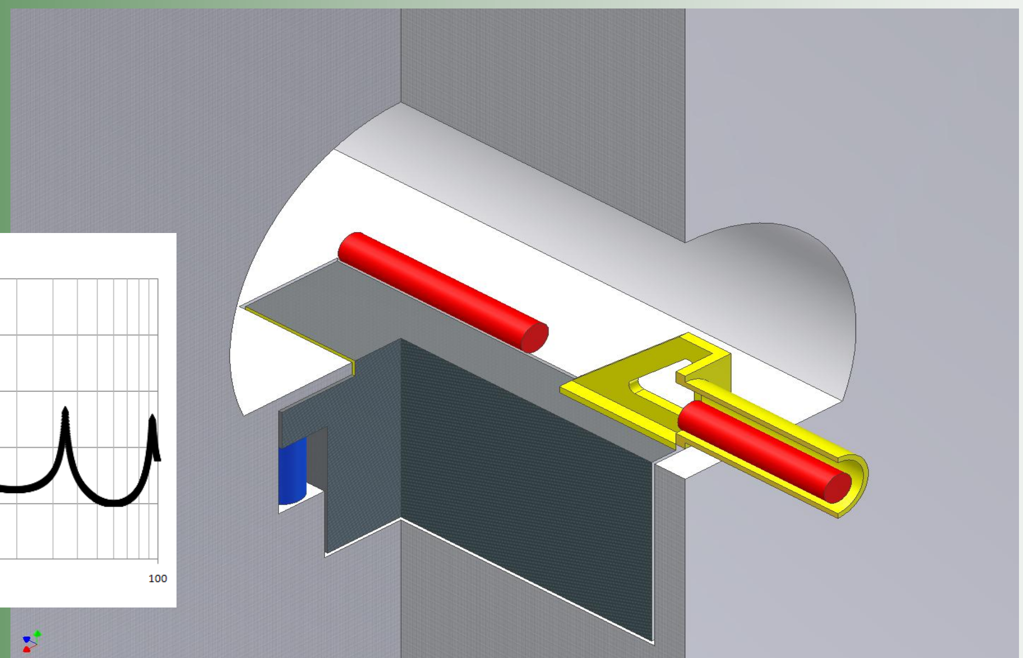
Passive isolation:
Pre-isolation for FF quads

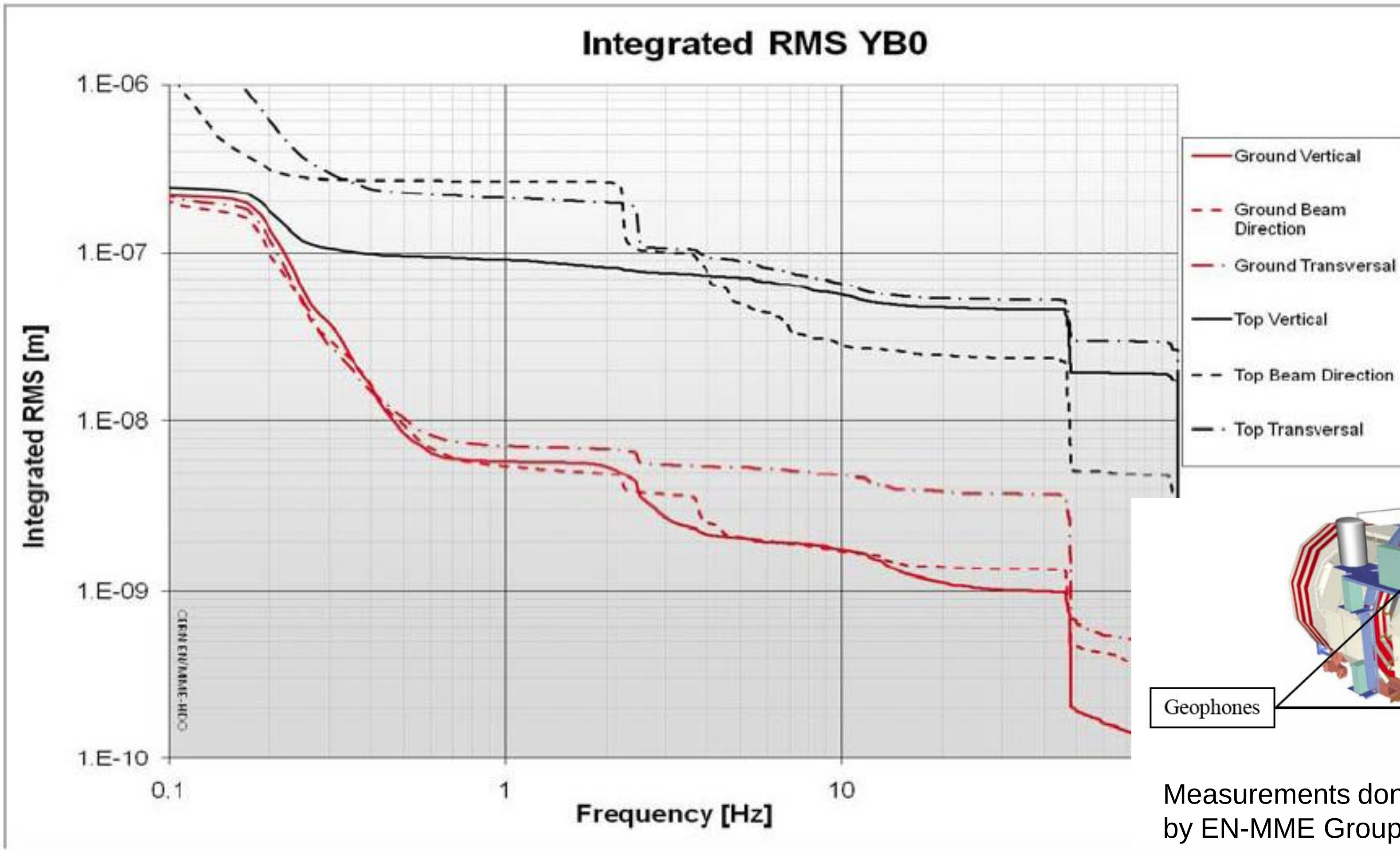


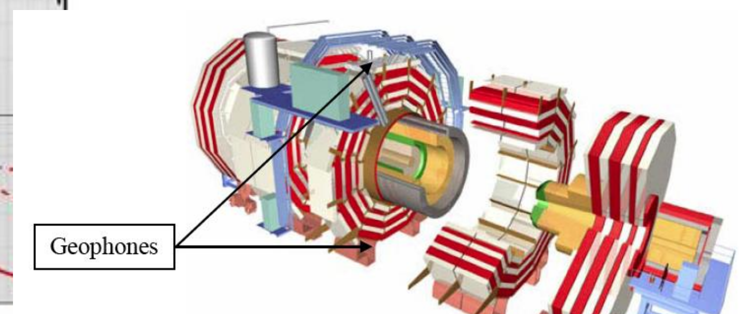


A. Gaddi, H. Gerwig, A. Hervé, N. Siegrist, F. Ramos

Retrospective view.

In the first CLIC MDI layout (legacy of ILC MDI), the QD0s were supported by the detector, or by a pillar on the detector moving platform. However it became clear, after the measuring campaign at CMS, that the vibrations generated by the detector itself would make impossible to achieve the stability requirements given for the FF magnets at CLIC.





Measurements done at CMS by EN-MME Group/CERN

Scope of work.

Try to attenuate, at its source, ground motion vertical excitations, in the range 1 – 50 Hz, to make life easier to the following stabilization systems.

Objective.

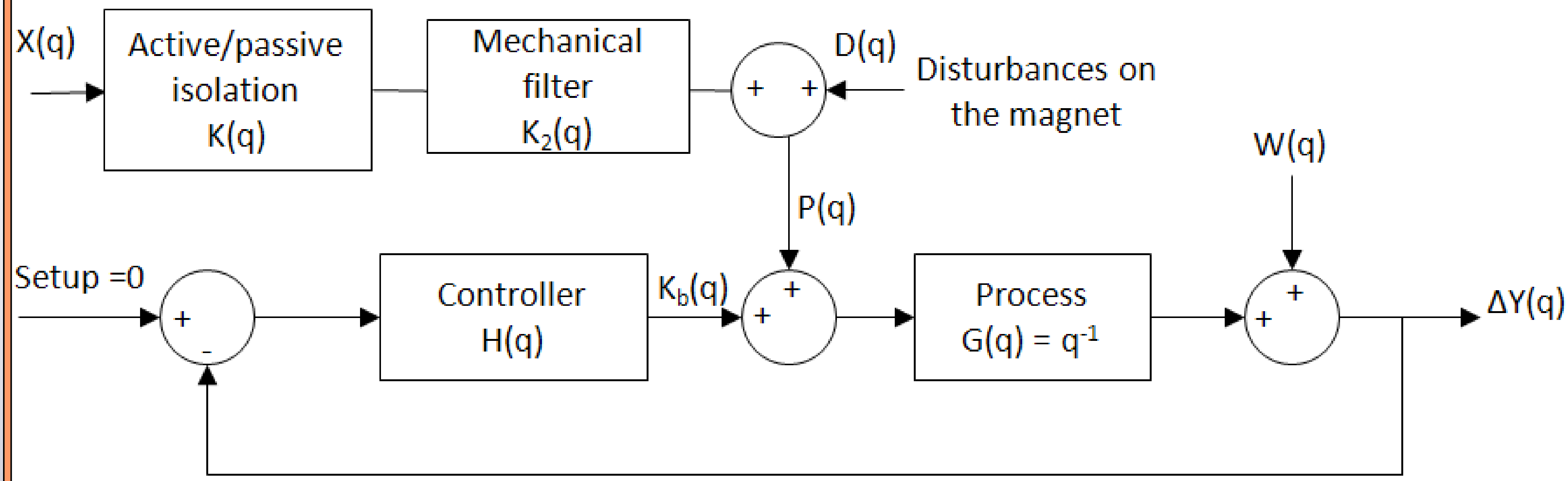
Stabilize FF magnets to better than 0.2 nm (rms) at 4 Hz, using an integrated approach of three systems, each one with its dynamic range and frequency response:

✧ Passive pre-isolator

✧ Active mechanical stabilization

✧ Beam-based stabilization

Stabilization block diagram.



X – ground motion
K_i – isolator transfer function
D – external disturbances else than ground-motion
W – white noise on beam position
ΔY – beam position signal

from B. Carron/CLIC Stabilization Working Group

Pre-isolator – How does it work ?

Low dynamic stiffness (k) mount + **Large mass (m)**

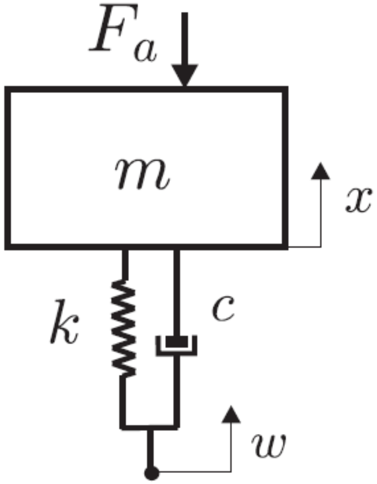
natural frequency around 1 Hz

between 50 and 100 tons

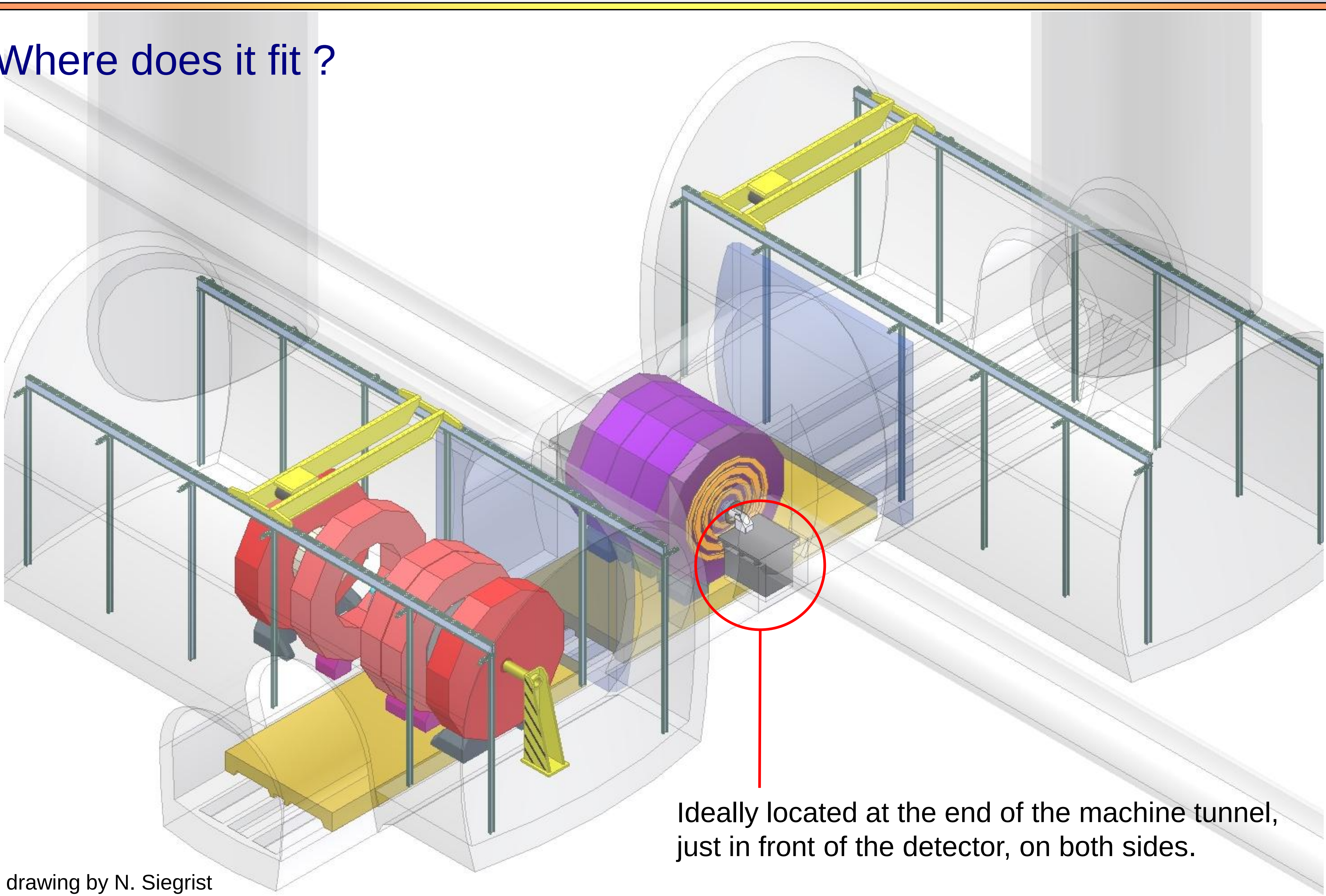
Acts as a low-pass filter for the ground motion (w)

Provides the inertia necessary to withstand the external disturbances (F_a), such as air flow, acoustic pressure, etc.)

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{k}{M}}$$



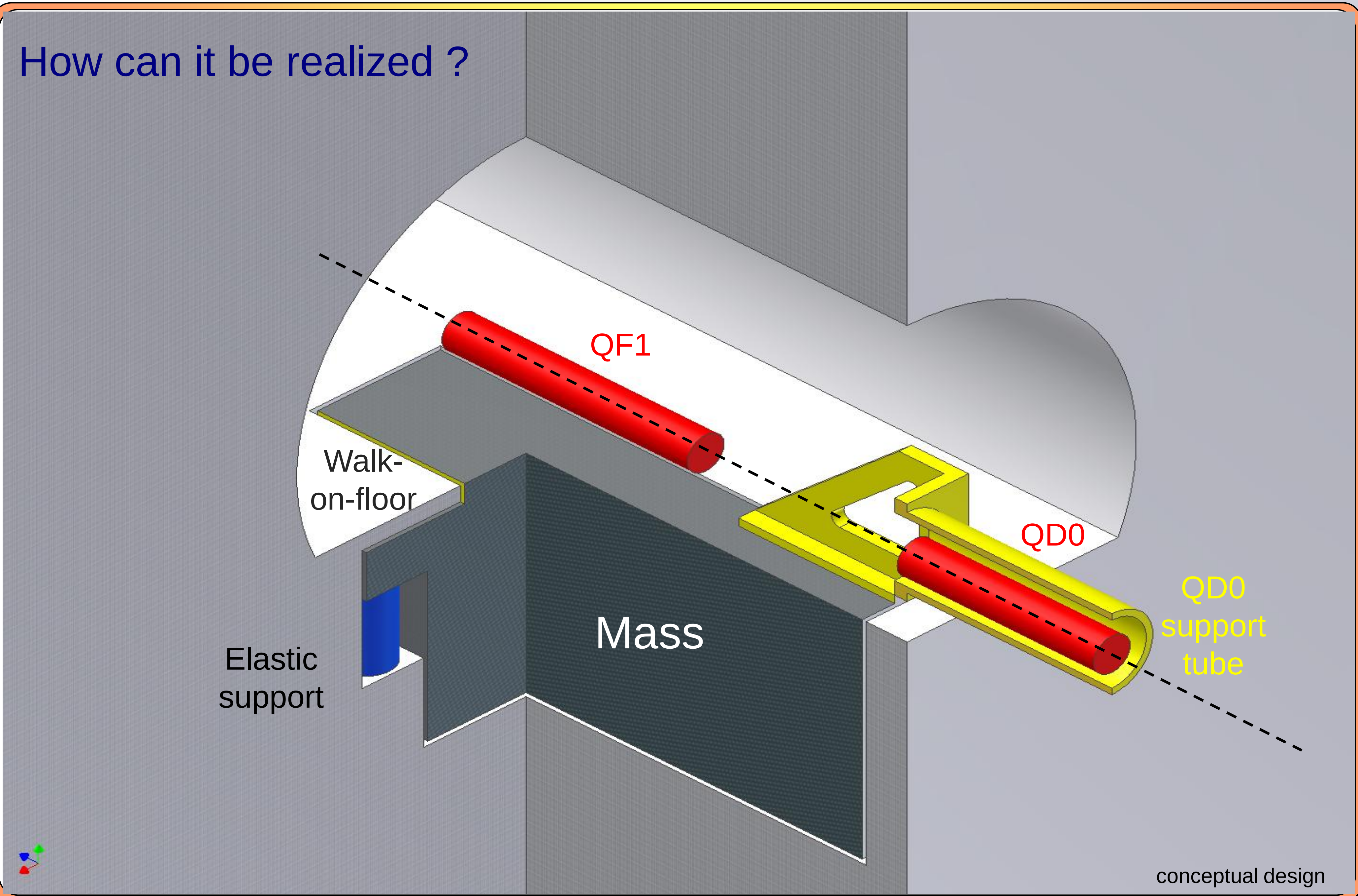
Where does it fit ?



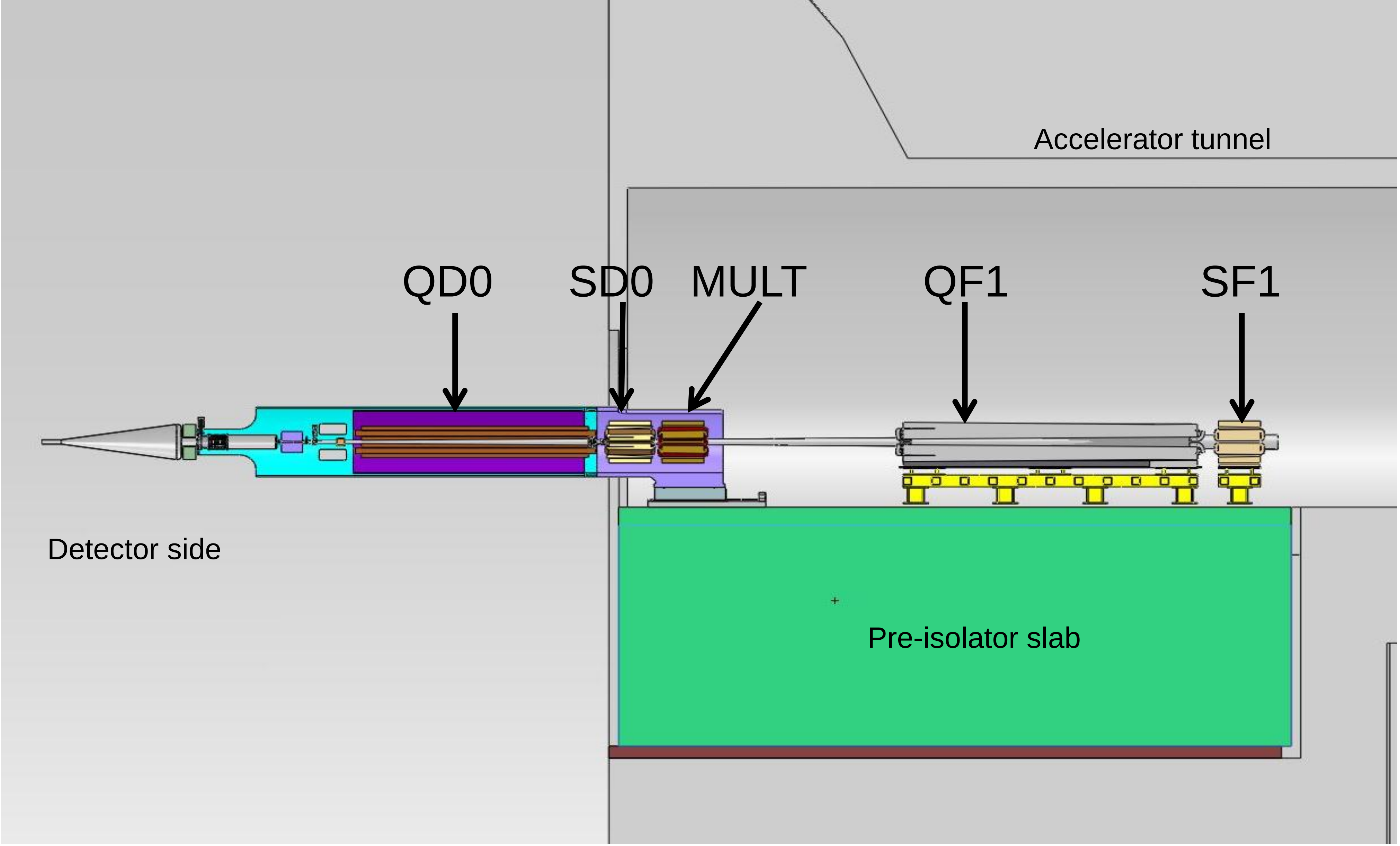
Ideally located at the end of the machine tunnel, just in front of the detector, on both sides.

drawing by N. Siegrist

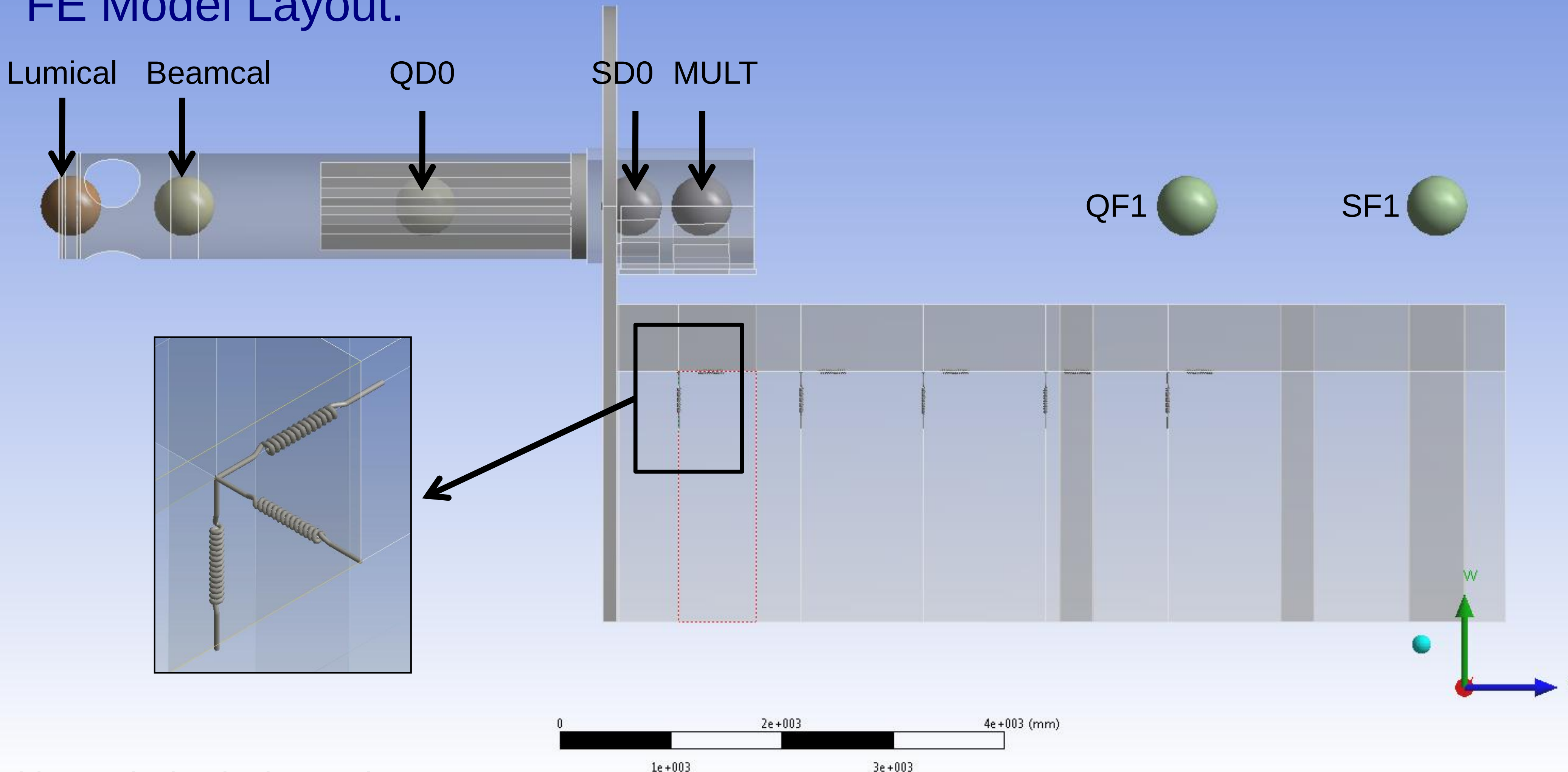
How can it be realized ?



More in details :



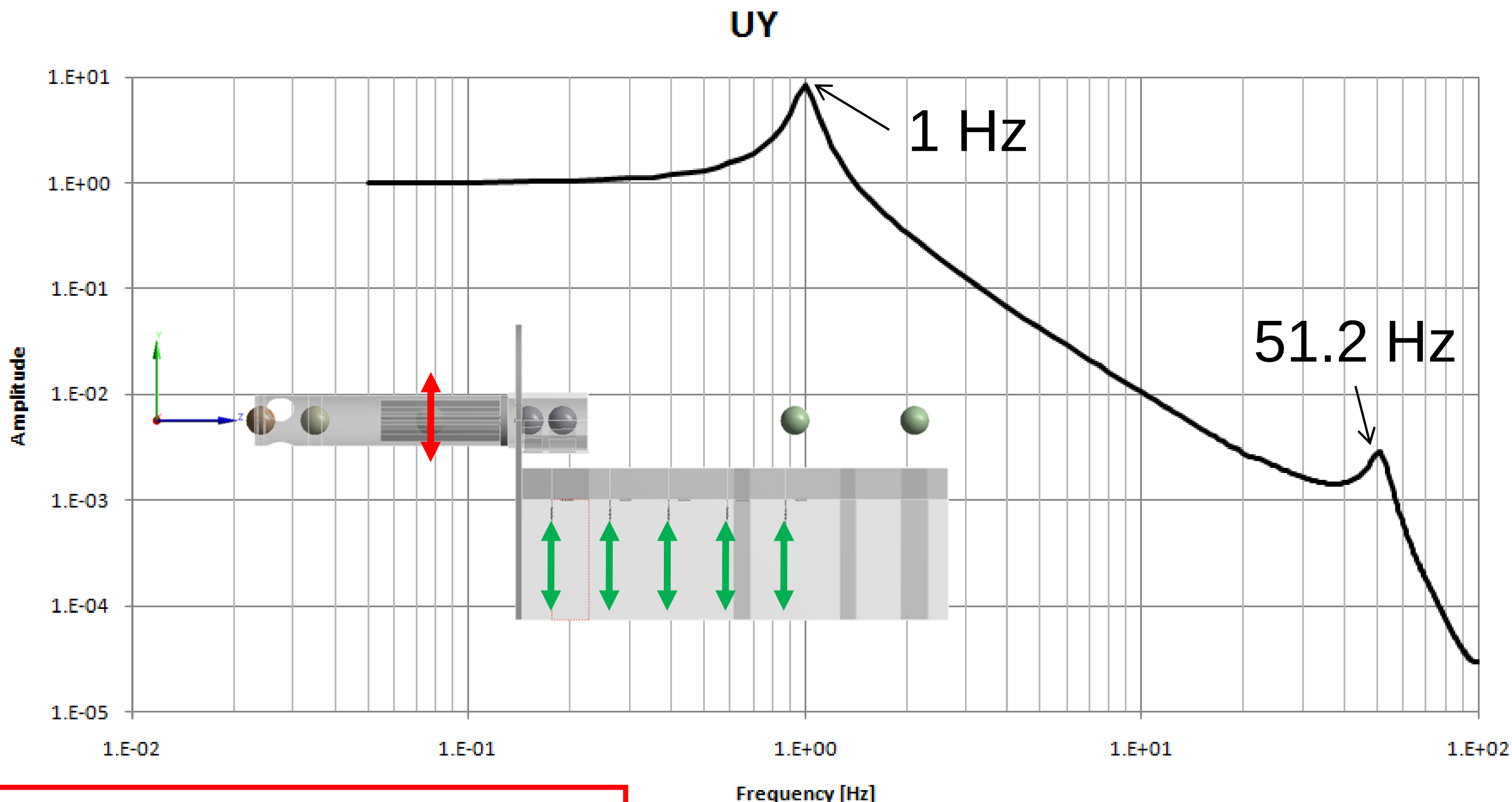
FE Model Layout.



Things missing in the model:

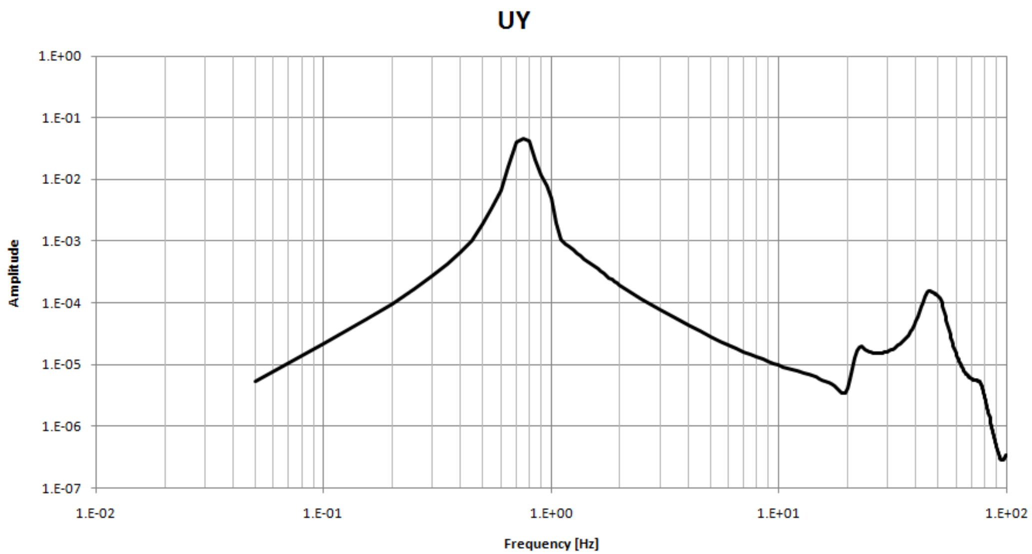
- Pre-alignment mechanics
- Final doublet's geometries (using, for now, 3-D point masses with estimated inertias)
- Final doublet's supporting structures (girders, etc.)
- Pre-isolator's supports (using , for now, 1-D springs with appropriate stiffness)

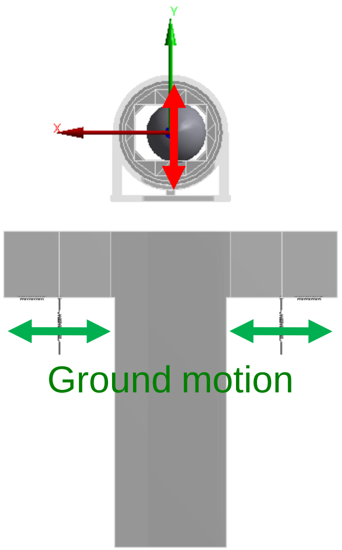
Response to excitation in the vertical direction.

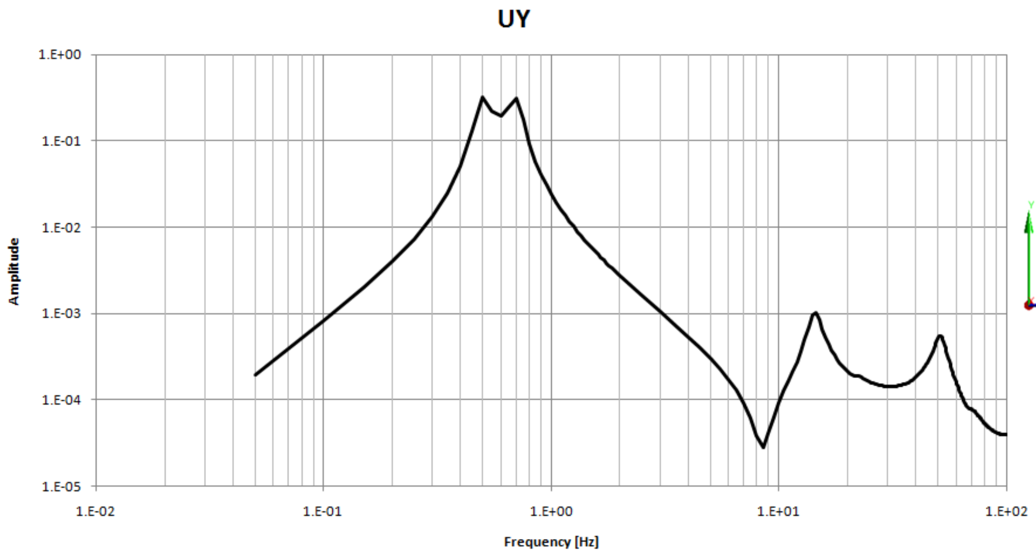


Good performance above the first resonance peak

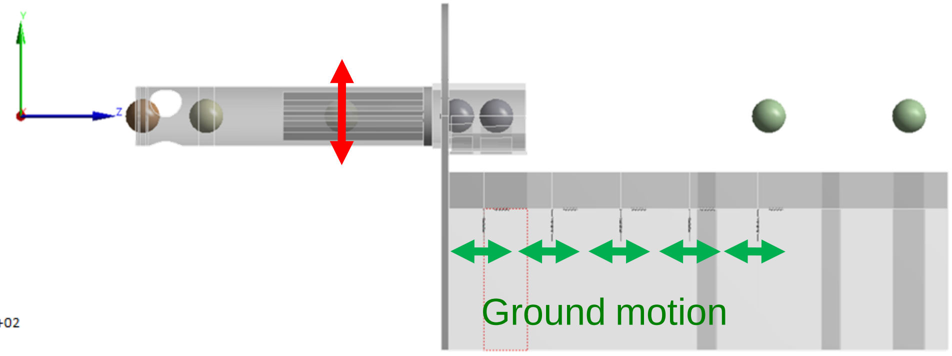
Response to excitation in the horizontal directions.



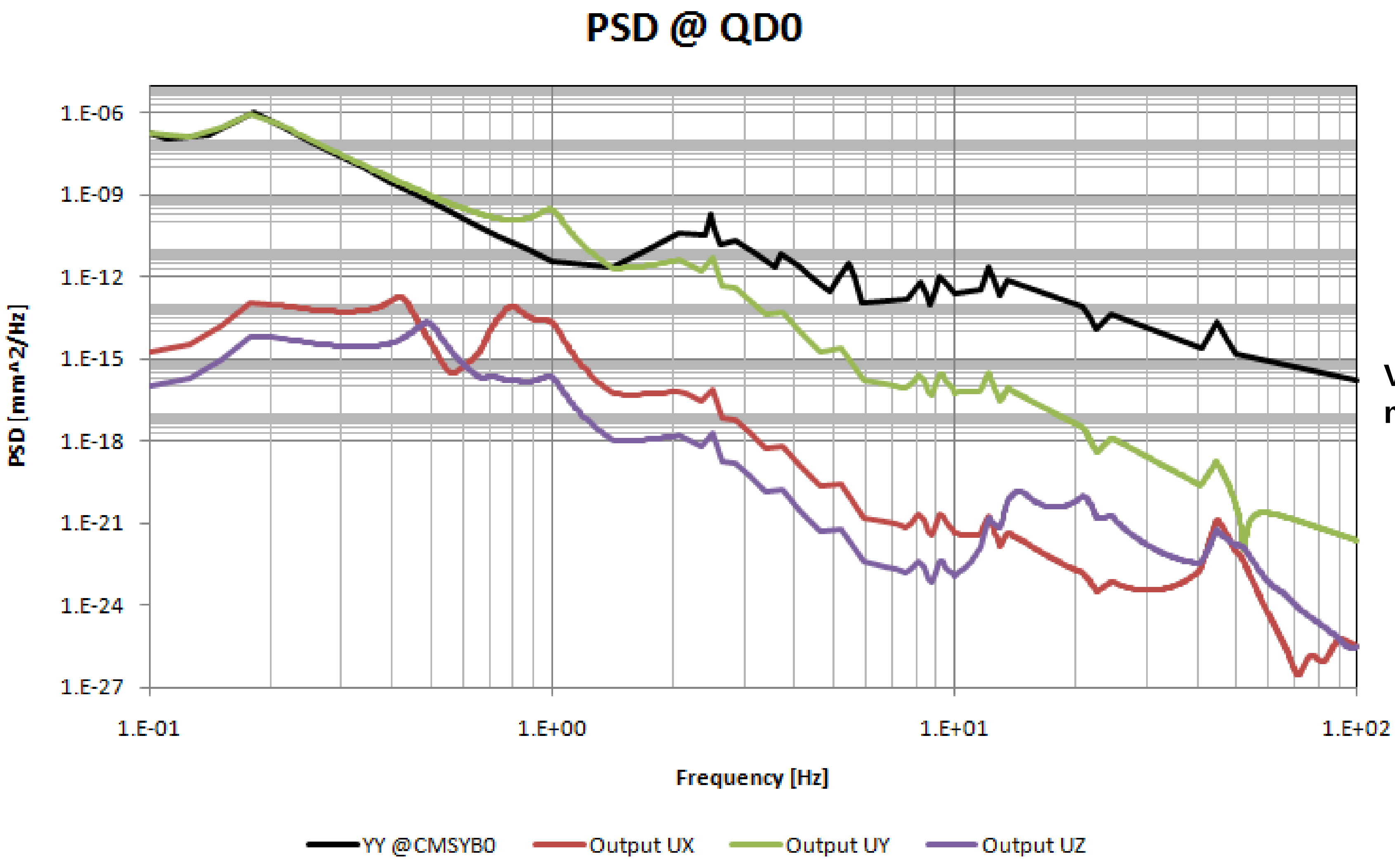




There is a good decoupling between horizontal & vertical directions

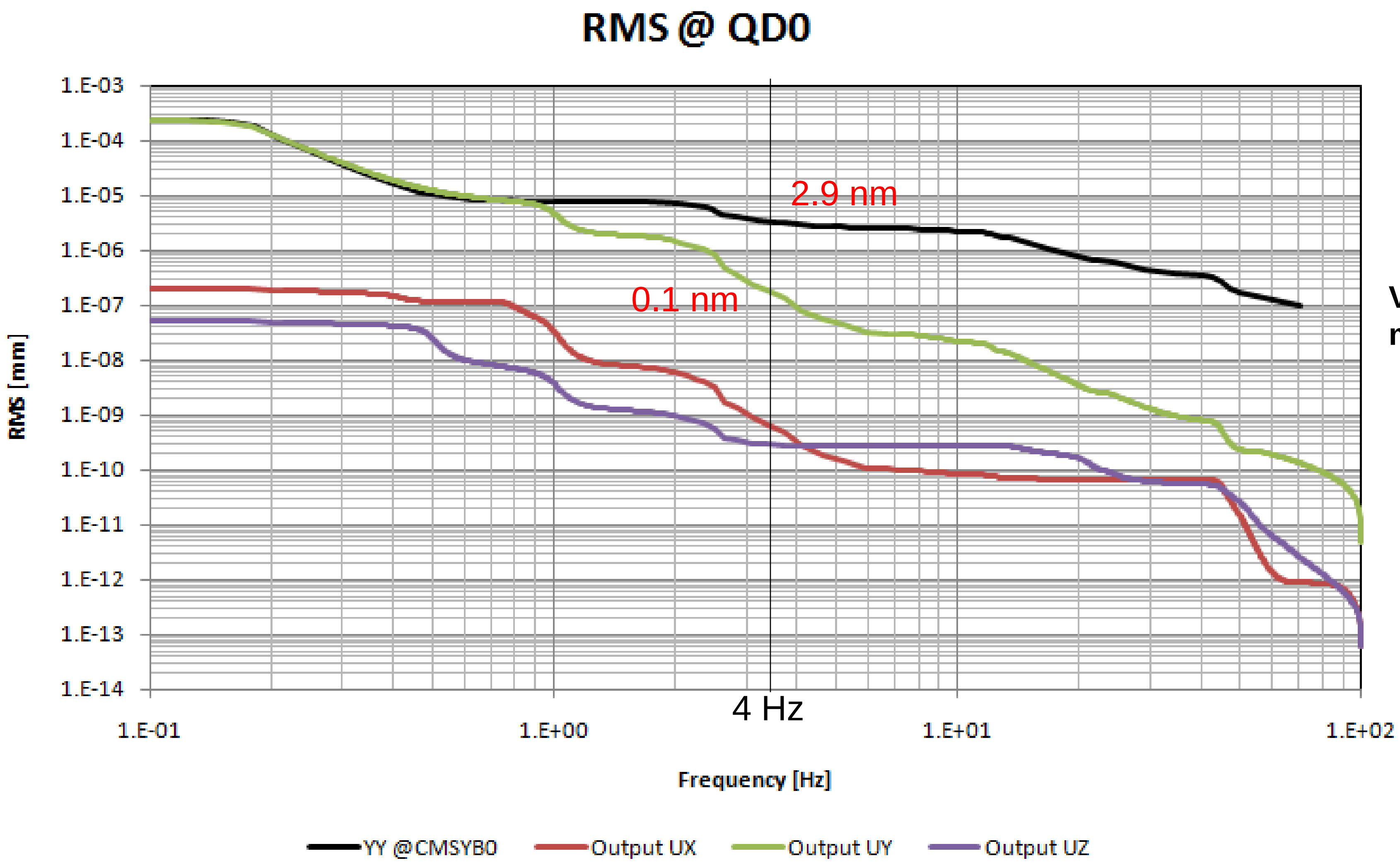


Random vibration response.



Vertical ground motion at CMS.

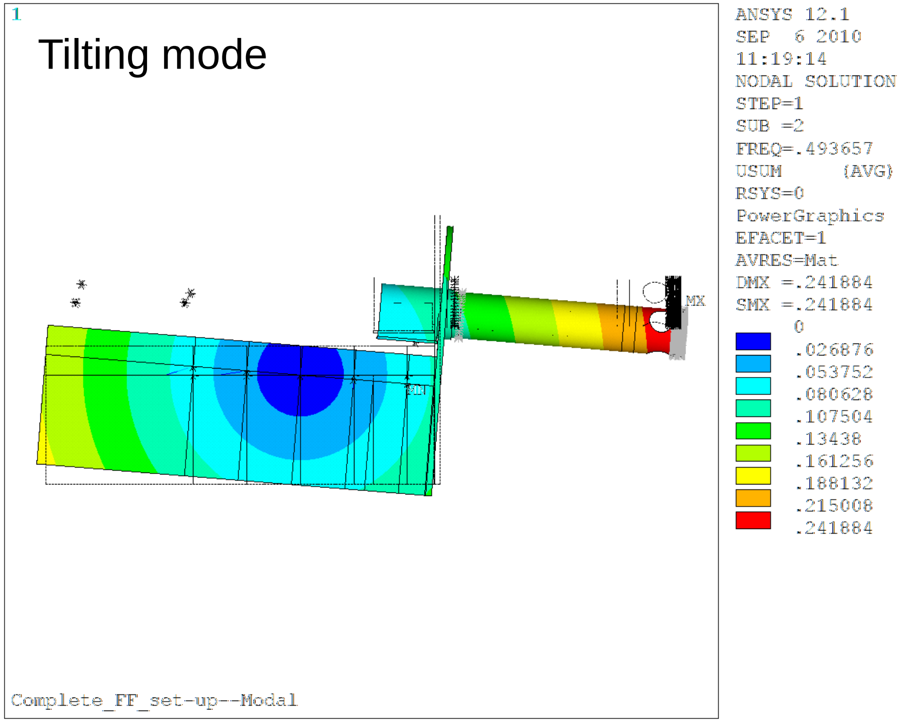
Random vibration response.

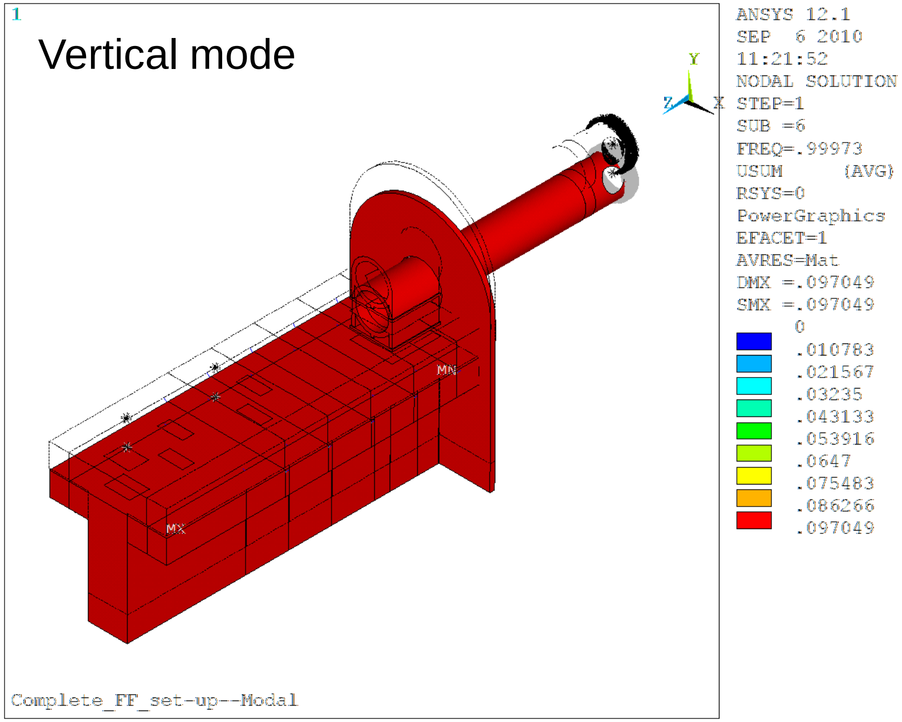


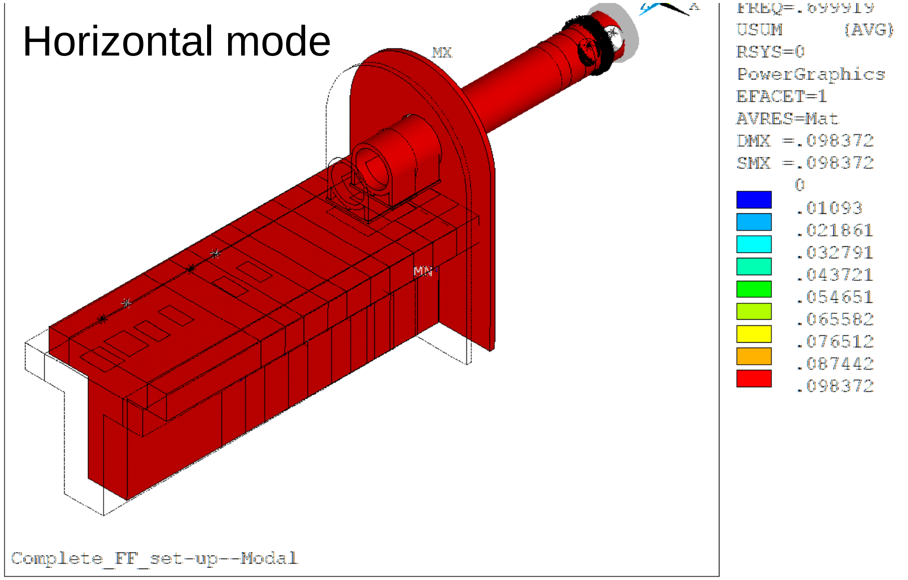
Vertical ground motion at CMS.

Reduction in r.m.s. displacements by a factor 30 above 4 Hz

Passive isolation: Pre-isolator for FF quads



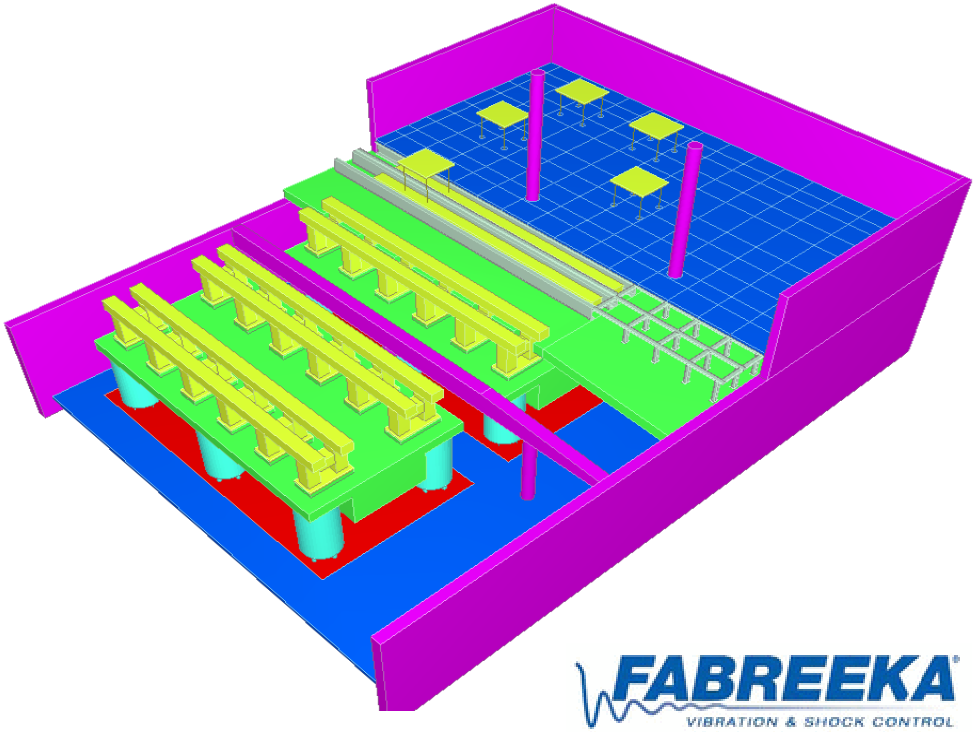




Example of pre-isolator application in industry.

Vibration isolation system at the Centre for Metrology and Accreditation – Helsinki, Finland

4 independent seismic masses (3x70 ton + 1x140 ton)



0.8 Hz pneumatic vibration isolators ("air springs")

Experimental set-up – Why ?

The idea is promising, but...

Is the system's performance amplitude dependent ?

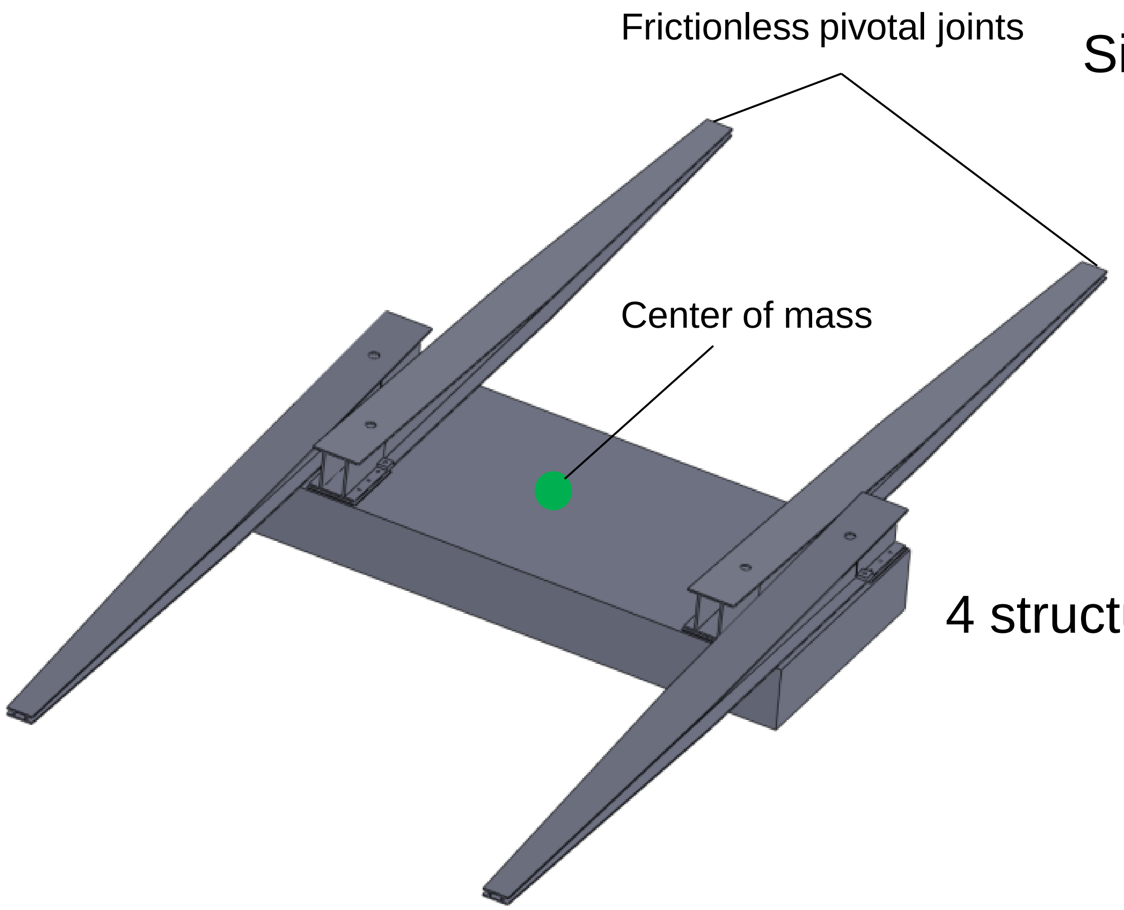
How will it react to different noise sources, else than micro-seism ?

What about energy loss mechanisms (friction...) ?

What performance can we expect ?

We have built a prototype to try to answer to these questions. Although rather different from the reference design, it will serve to validate the idea of having a low-frequency mechanical filter in front of the FF stabilization chain.

Experimental set-up – How ?



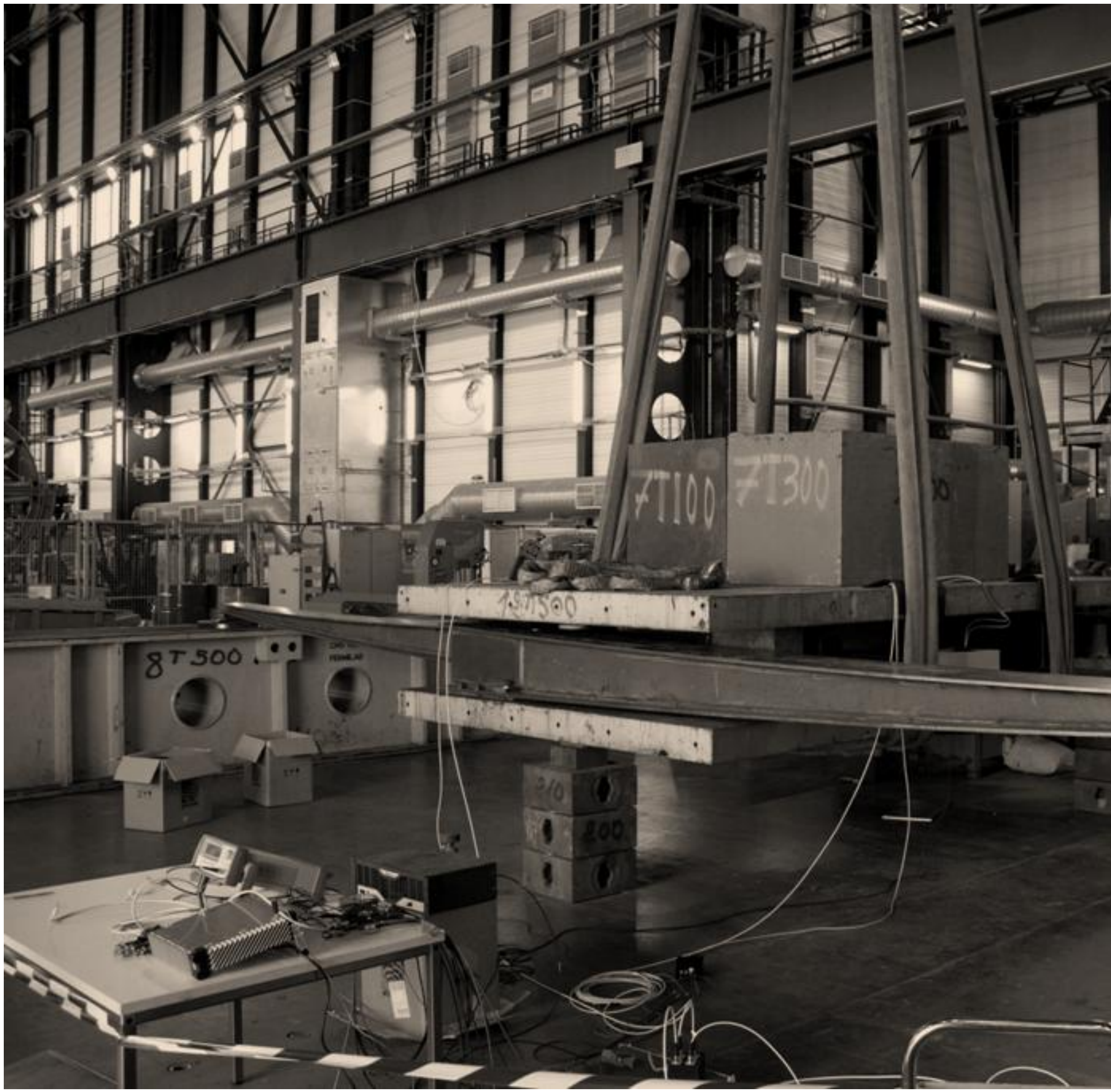
The prototype needs to be:

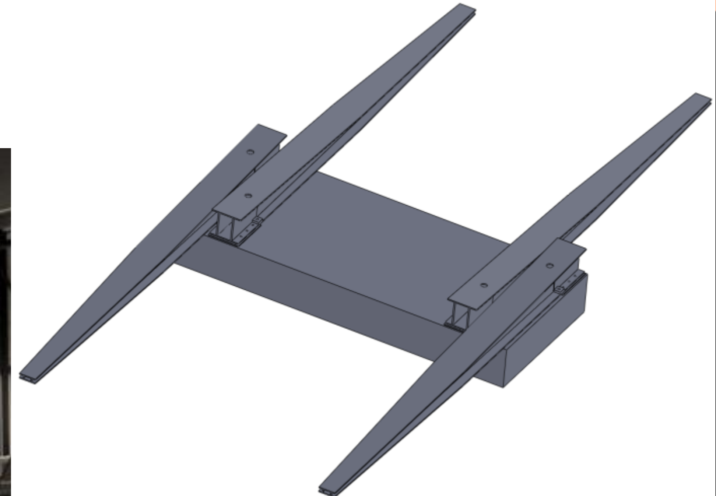
Simple to design/build/assemble
Easy to "debug" & tune
Cheap

Proposal:

40 ton mass supported by
4 structural beams acting as flexural springs

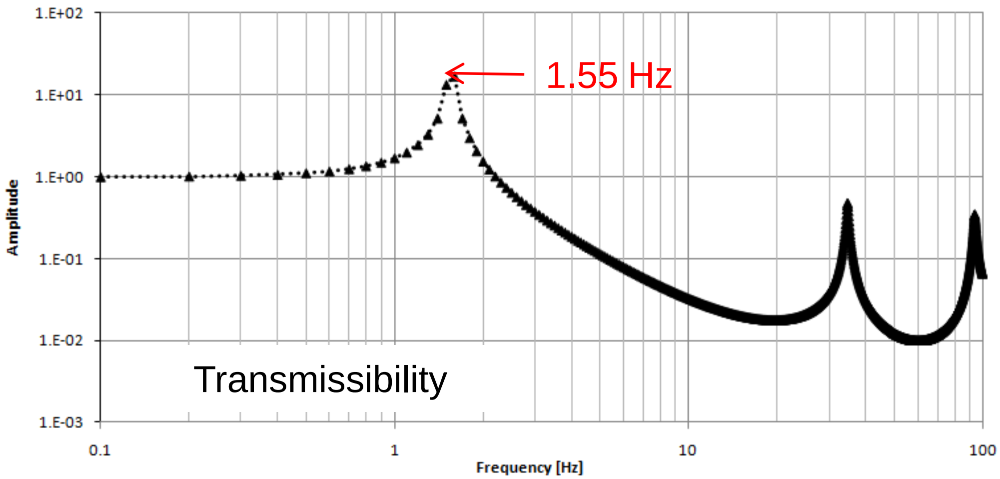
Photo of the prototype.

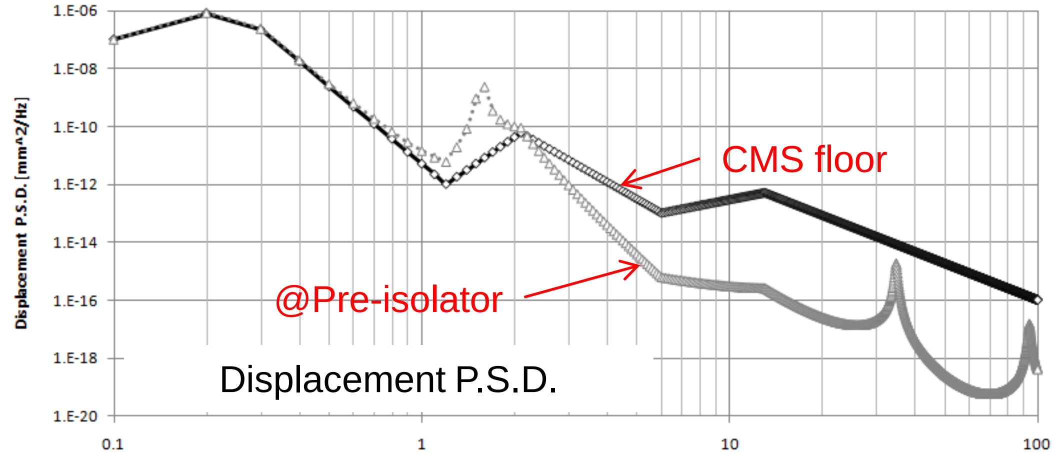


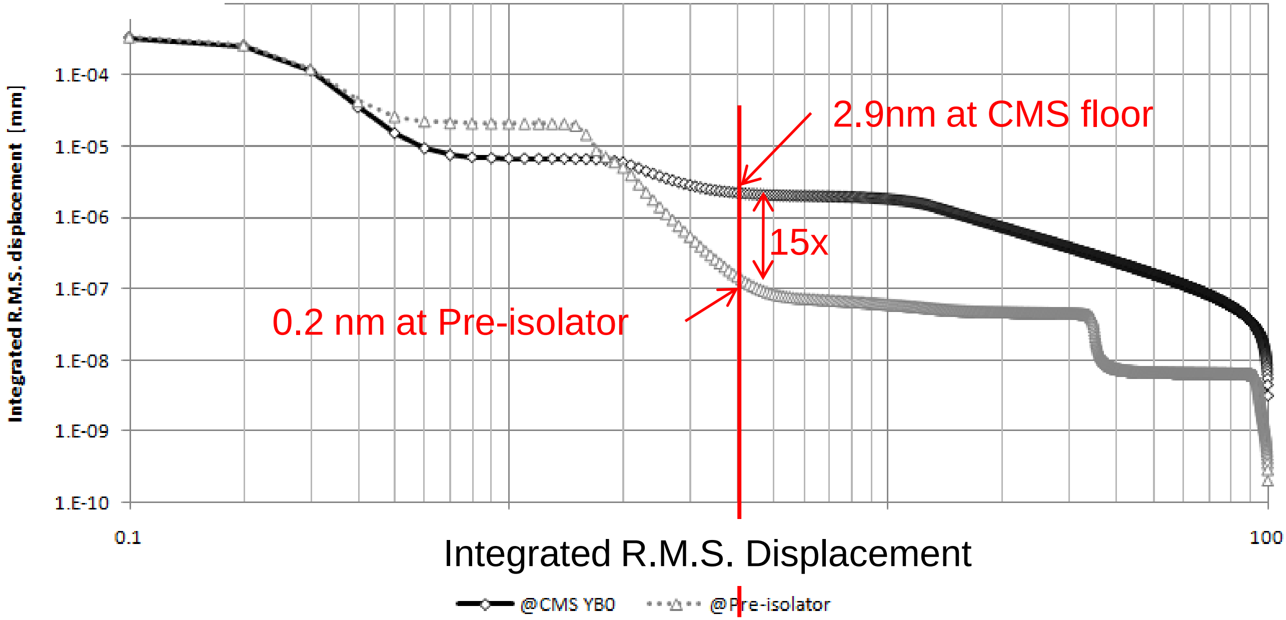


Experimental set-up – expected performance.

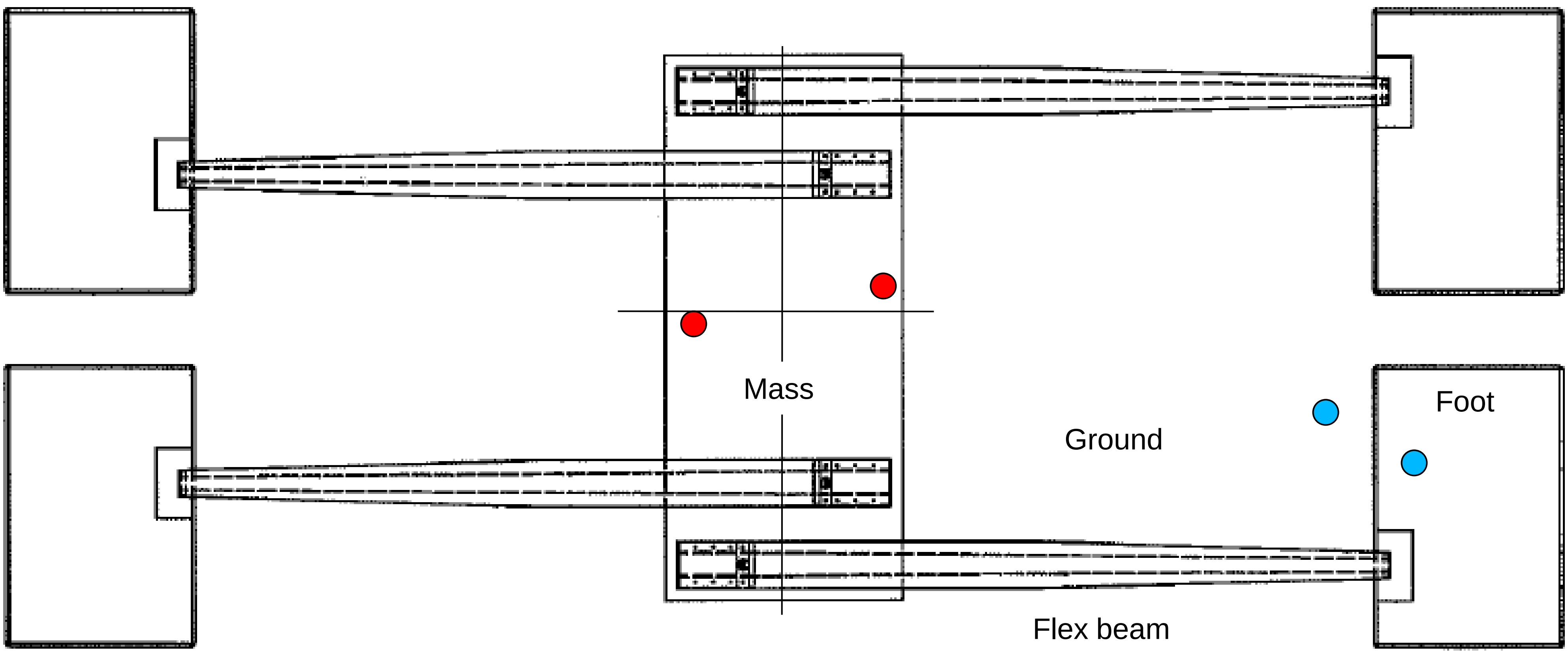
Performance in ideal conditions (ground motion only).



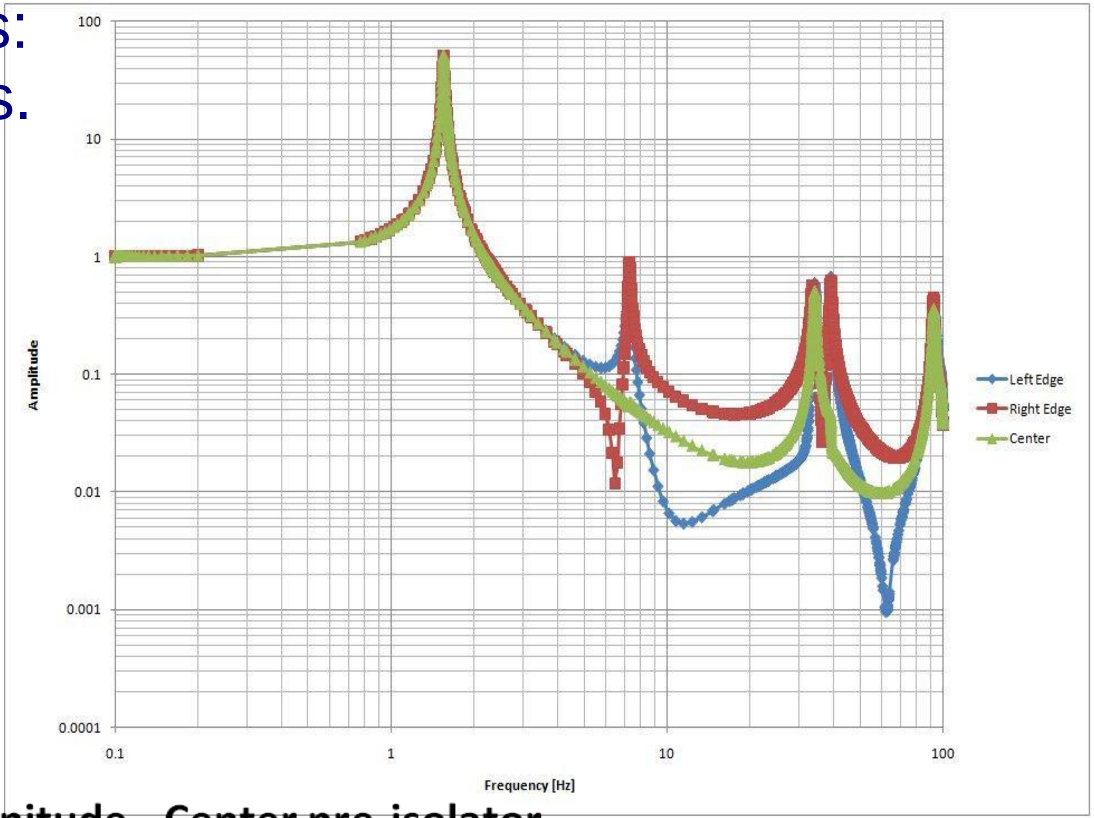


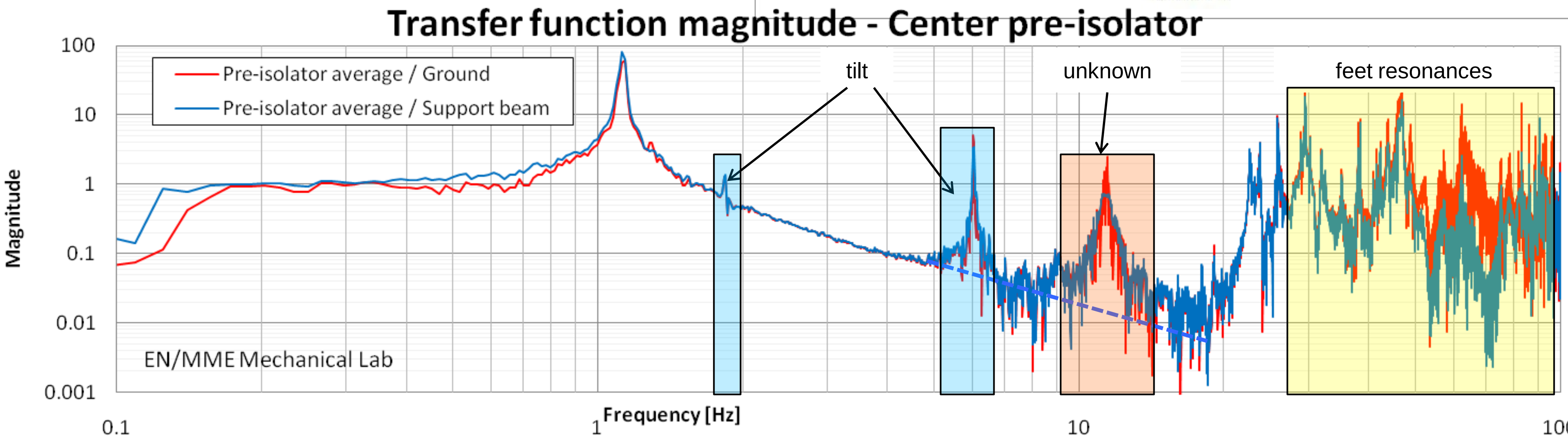


Experimental set-up – position of the vibration sensors.



Experimental setup – first results: reconstructed center movements.





Future plans.

- A passive low-frequency pre-isolator has been proposed as a support for the FF magnets. It can be integrated at the interface between the machine tunnel and the detector cavern.

- This pre-isolator will constitute the first “layer” of the stabilization chain.

- This concept has already been used in other industrial and research facilities.

- Experimental tests will be performed to understand how the system behaves in “real life” conditions (no simulation can accurately take into account all these effects). A simple and relatively inexpensive experimental set-up has been conceived and built. Measurements are under way.

- Further studies are necessary to integrate the pre-isolator with the civil-engineering and the other MDI systems (pre-alignement, FF magnets, forward detector region, beam-pipe, etc…)