Laboratoire d'Annecy de Physique des Particules

Mini workshop - May 11, 2022

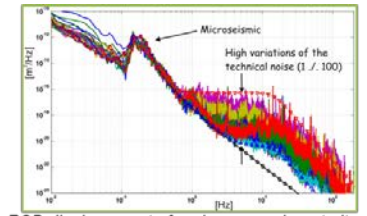
L. Brunetti et al

cnrs

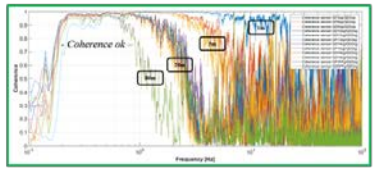
UNIVERSITÉ SAVOIE MONT BLANC

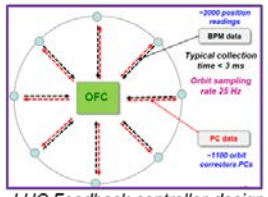
Alignment with static and dynamic aspects vs vibrations mitigation

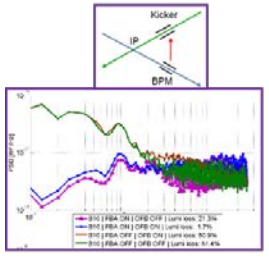
- **FCC-ee vibrations studies :**



PSD displacement of various experiment sites

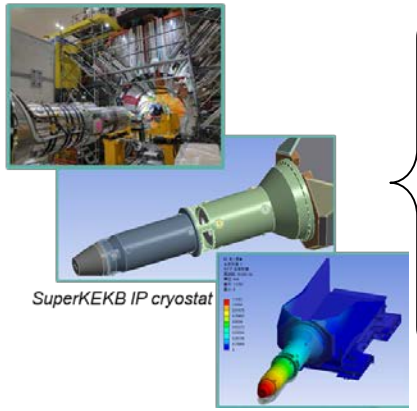

ATF2 coherence


LHC Feedback controller design


CLIC post IP BPM feedback


LHC Beam Position Monitor


Vibration sensor


SuperKEKB IP cryostat

- Concrete
- **Positioning system** & alignment
- Girder
- **Cryostat support**
- Coupling Cryostat - magnet
- Magnet

Vibrations control strategy (beam control, active control, coherence optimization…)

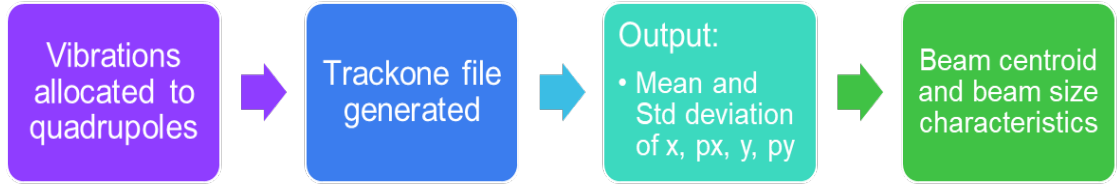
- ❑ Static alignment: rigid
- ❑ Dynamic positioning: eigenfrequencies

- ➢ Complementary study to the current ones dedicated to the optics simulations (T. Charles, K. Oide et al)
- ➢ E. Montbarbon, “MAD-X Simulations of vibrations in the MDI region”, FCC IS meeting 2021 & MDI FCCee meeting 2022 April 11

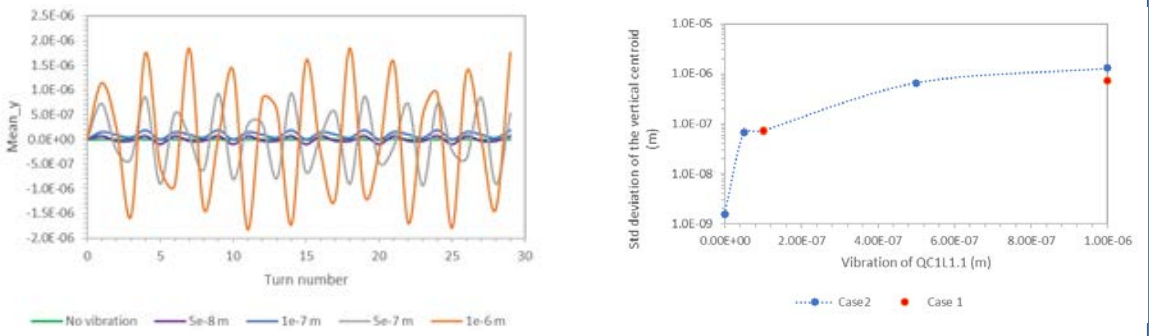
FCC-ee MDI vibration simulation studies (E.Montbarbon)

- **Aim:**
  - Quantify the impact of vibrations of the MDI quadrupoles on beam characteristics
- **Complementary study to the performed misalignments study**
- **Tools:**
  - Z lattice (91km), optics simulation with MAD-X

- **MAD-X simulation:**
  - Preparation of the MAD-X routine
    - Tracking of particle bunches over several turns
    - Displacement of quadrupole(s)



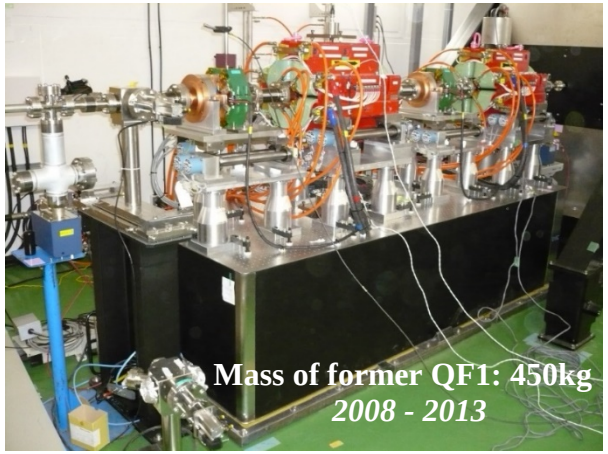
- **Initial study to test algorithm:**
  - Perfect machine (no misalignments), though no closed loop
  - Sensitivity of the lattice to a first single step displacement
    - Oscillation of centroid over turn increase with displacement
    - Divergence increases over turn (time)



- **Work in progress:**
  - At the very beginning of vibration studies:
    - Still a lot to do on the routines (external python code for displacements and functions)
  - Turn i.e. timing has to be put in, towards frequency domain for the vibration

Example: ATF2 Final Doublets vibrations mitigation

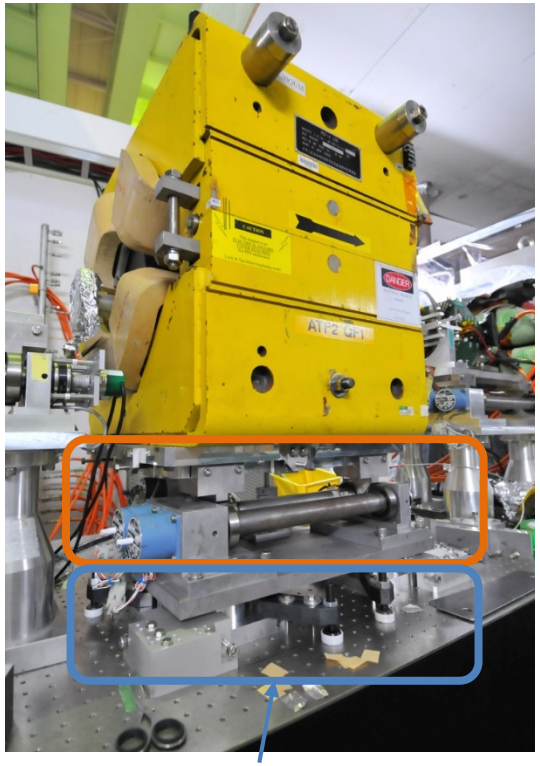
- **Integration of a new QF1 or magnet L***



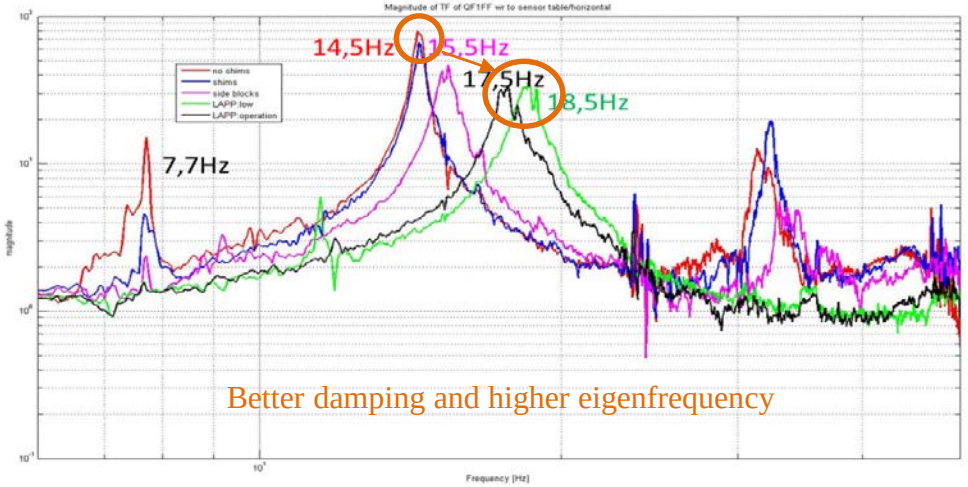
Remote alignement ok
Vibrations ok

Remote alignement~ok
Vibrations not ok

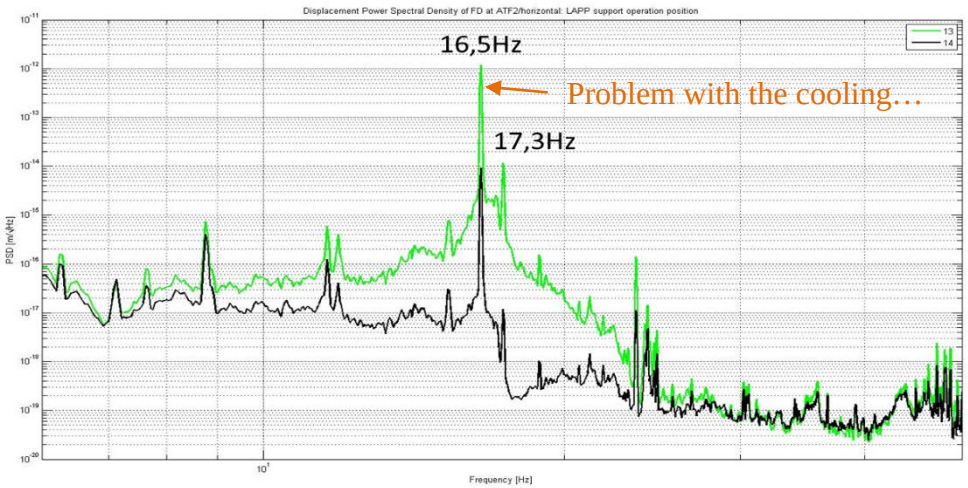
Relative vertical measurement
SM – QF1: 6,3nm -> 30 nm



New support - 2015



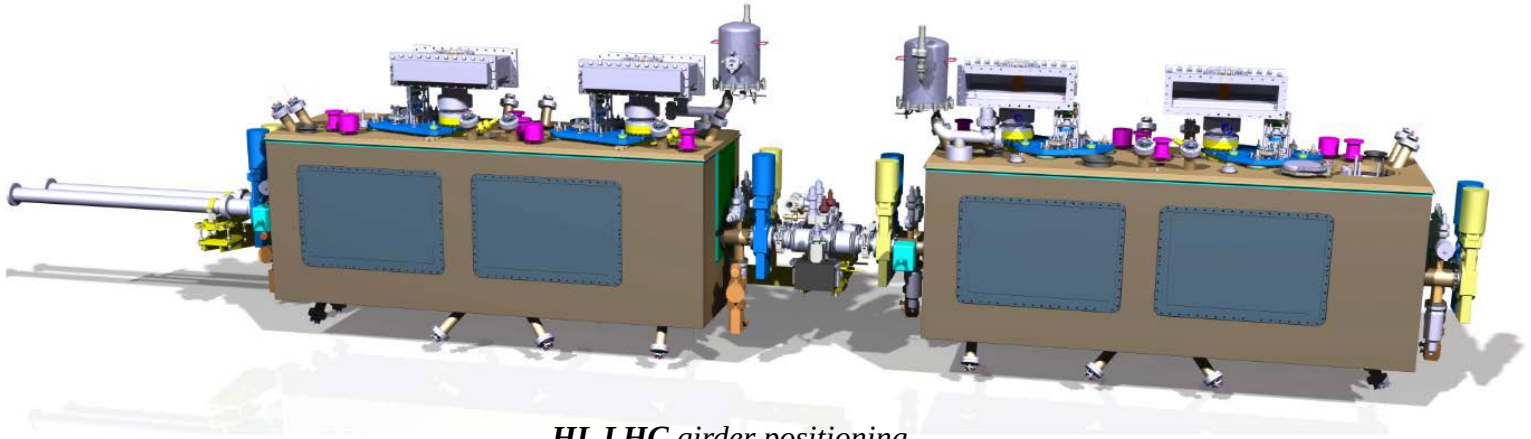
Transfer functions in horizontal direction (6-50Hz).



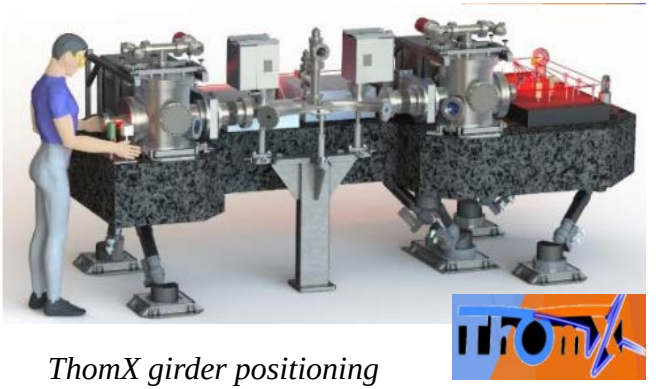
PSD in horizontal direction (6-50Hz) (after the upgrade).

Positioning with hexapods or specifics feet

- **Some examples of solutions:**



HL LHC *girder positioning*



ThomX girder positioning

CLIC *Main Linac stabilization and final positioning - CERN*

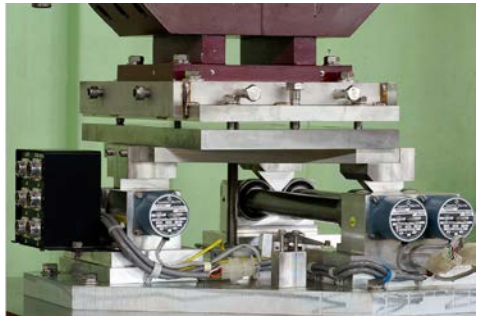
Individual mirror positioning

➢ **Specifications vs induced vibrations in function of the solutions (vs cost, resolution, load, dimensions, eigenfrequencies…)**

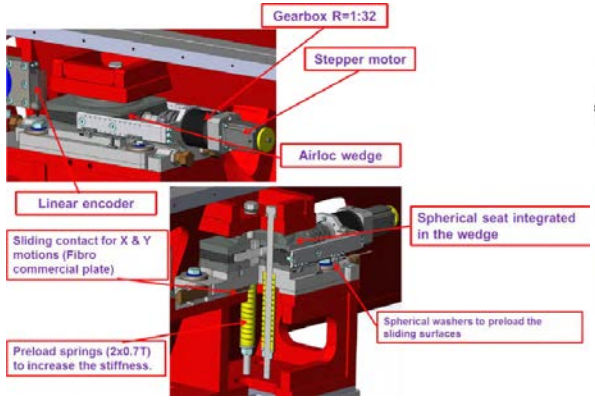
Positioning with cam movers or precision levelers

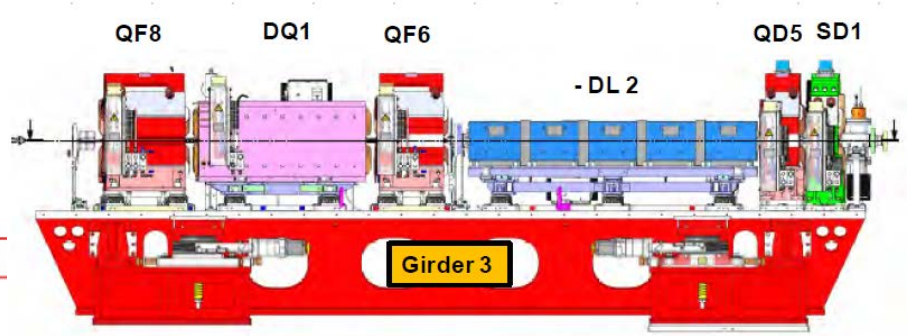
- **Some examples of worldwide solutions:**

  Positioning of magnets (ATF2, CLIC) and / or girder (ESRF, SLS,… and FCCee) with or without parallel stiffness

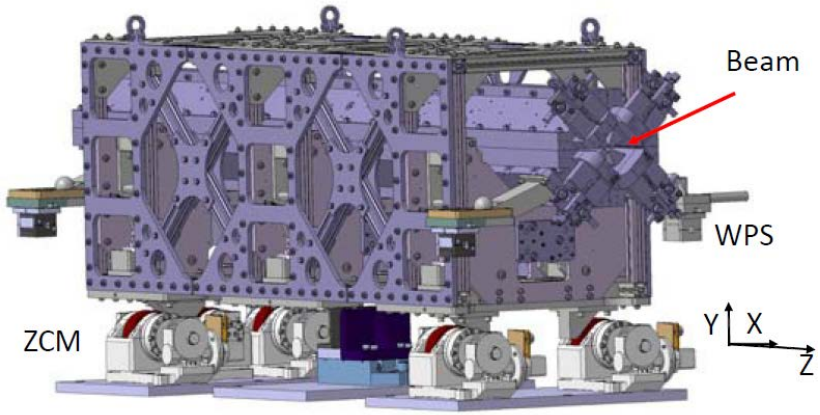


Magnet mover mechanism (from FFTB, SLAC)

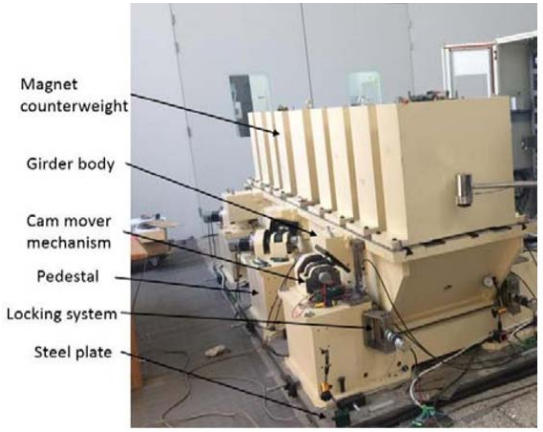




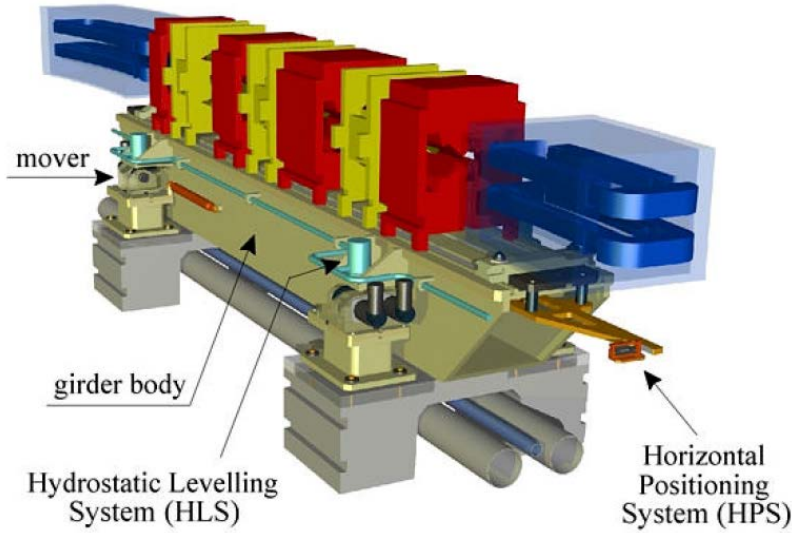
ESRF : girder positioning



CLIC : Type 4 MBQ and stabilization system mounted on cam movers



Magnet Girder Prototypes for HEPS-TF



SLS storage ring girder assembly at PSI

- *G. Balik et al, FCC-ee beam diagnostics, beam tests, and support structures (a dynamic positioning strategy), FCC IS kickoff meeting, 2020 November 10*
  https://indico.cern.ch/event/923801/contributions/4084997/attachments/2139774/3605408/FCC-ee%20KickOFF%20meeting%20nov%202020%20Gael%20Balik.pdf

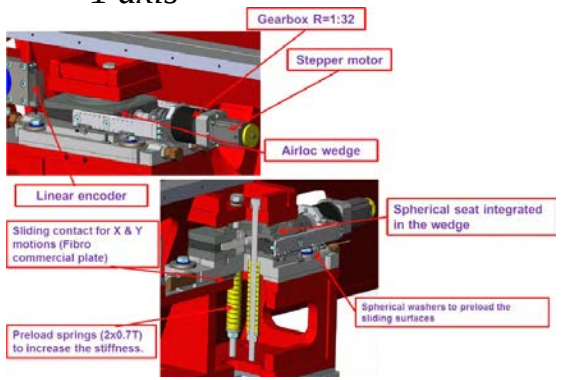
Test opportunity : ATF2 Final Doublets vibration mitigation

- **Research of a compact, functional and cheap solution :**

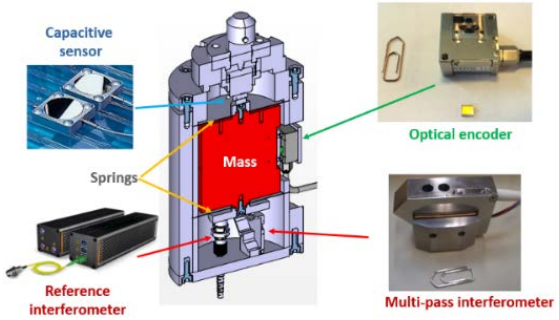
ATF2 specifications: accuracy of 1-2 µm and a resolution of about 0.04 µm

ESRF Solution:

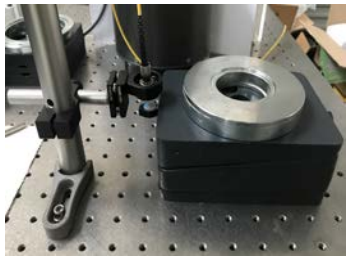
- *Industrial levelers*
- *Measured accuracy < 1 um*
- *1st mode > 35 Hz*
- *1 axis*

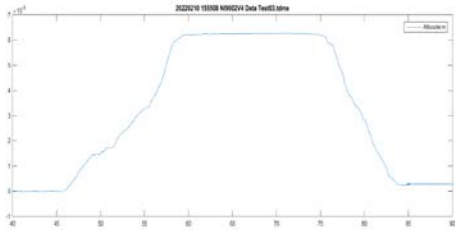


With interferometry measurement (R&D vibrations sensor)



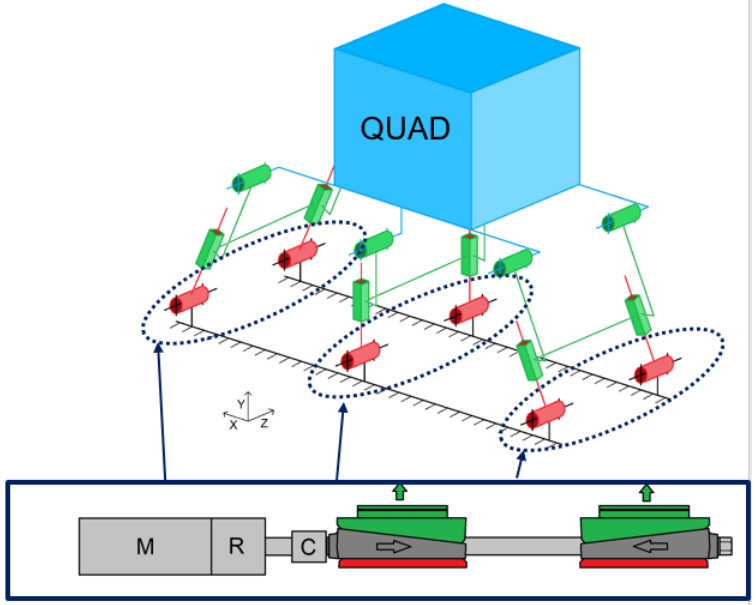
And expertise in automation and mechatronics



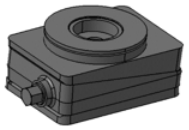


Preliminary tests

Improved and motorized leveler

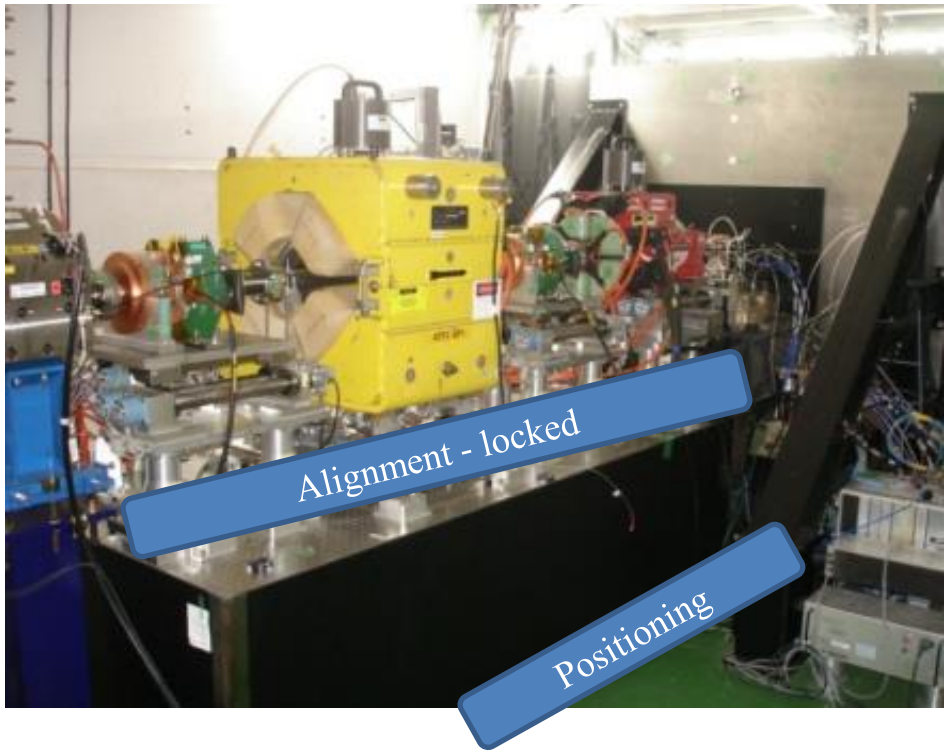


Idea: 2D platform with parallel stiffness and dedicated junction element



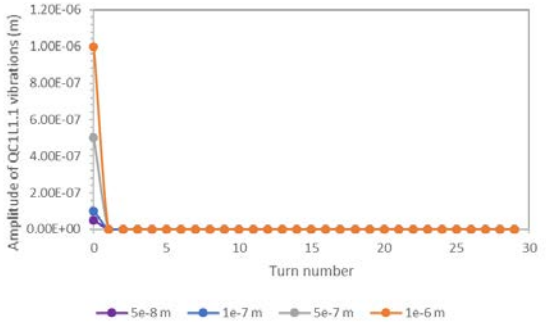
Conclusion

- Active positioning (beam ON) is the interface between alignment (static) and vibrations mitigation
- The transfer functions of the positioning systems are very important in the whole dynamic of the mechanical assembly
- A positioning solution is in progress at LAPP and has to be evaluated in taking into account the resolution, cost, dimensions, quantity, load and transfer function…
- ATF2 / ATF3 could be also a test bench for a positioning girder system



Spare

First study case (3)

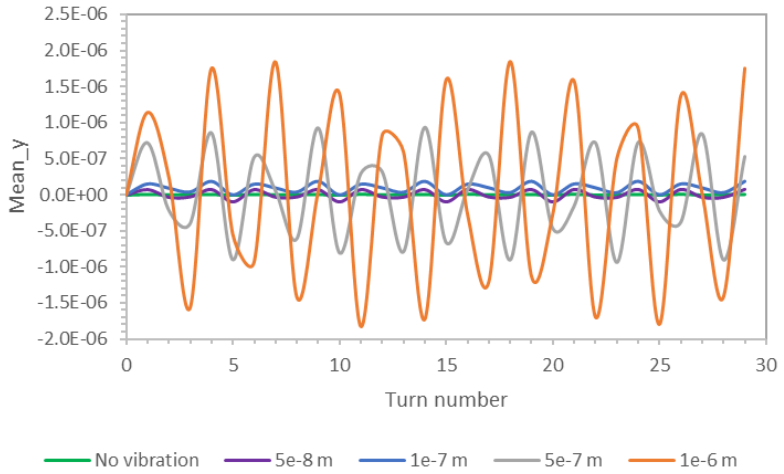


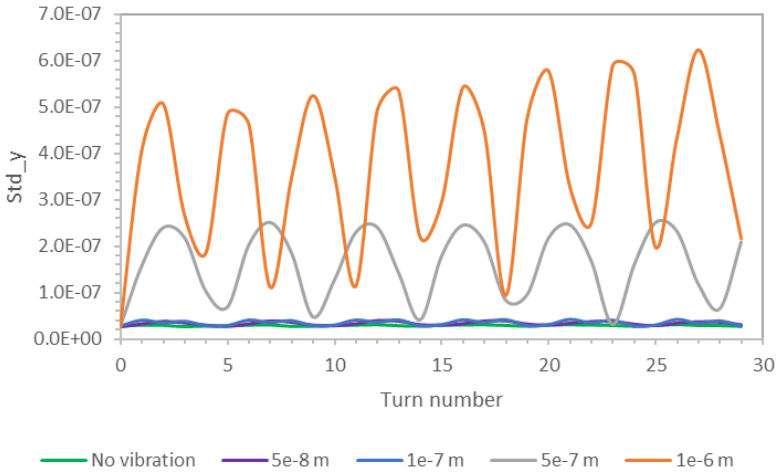
- **Results** (2)

Beam centroid:

Beam size:

y offset:





py: