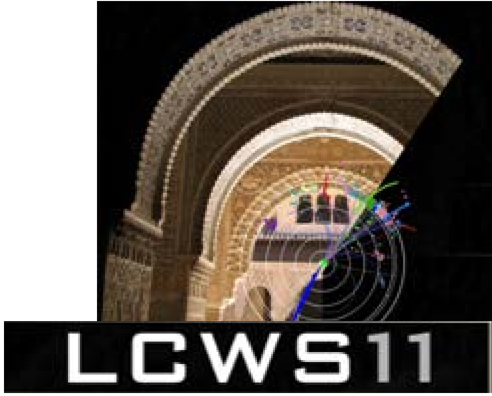


CLIC MDI stabilisation studies

Andrea JEREMIE

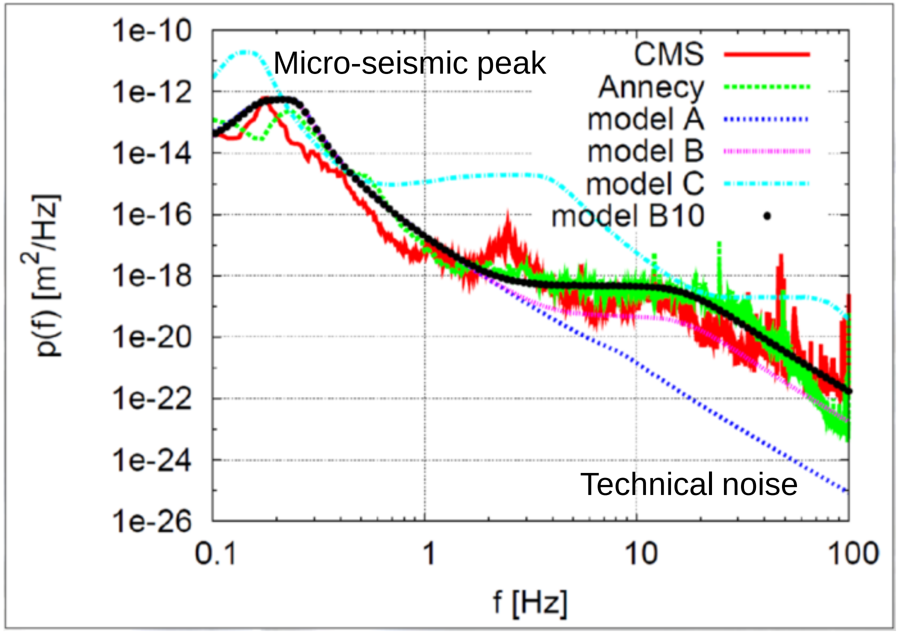
A.Badel, B.Caron, R.LeBreton, J.Lottin,
G.Balik, J.P.Baud, L.Brunetti, G.Deleglise, (L.Pacquet)
And other discussions and work from others involved

Outline

- What we are aiming at
- Solutions considered for FF
- Current studies on active stabilisation
- LAViSta IP feedback design (50Hz) and integrated simulations
- Outlook

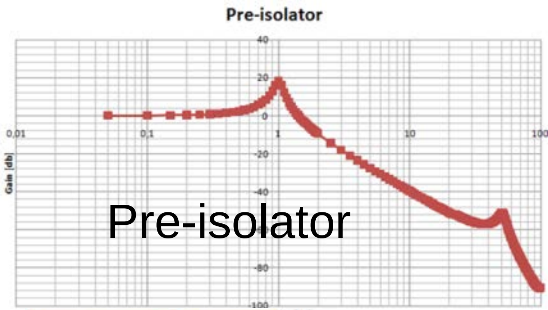
What we are aiming at

- Ground motion can have an impact on luminosity
- Critical region of stabilisation around 1-30Hz
- Typical quadrupole jitter tolerance O(1nm) in main linac quadrupole and O(0.1nm) in final doublet
- FF aiming at 0.15nm integrated rms above a few Hz (4Hz to compare to previous studies) for the mechanical stabilisation of quadrupole magnets (guiding the beam)
- Band-width of stabilisation study 0,1-100Hz although higher frequencies can have an impact (acoustic noise…)

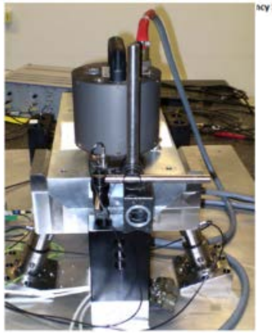


Solutions considered for FF

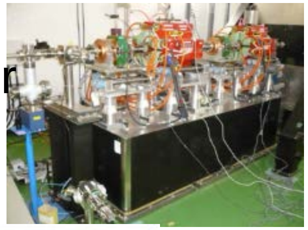
Type	Caracteristic	Drawback
Soft passive solution	Rubber, pneumatic actuators… Maximize isolation from ground motion	resonance peak in region of interest, Low stiffness
Active solution	measure perturbation and act consequently on system (real time solution)	need to act efficiently on a large band-width
Rigid passive solution	maximize coherence for optimal alignment	no possibility of action if needed
Combine passive solution and active solution for CLIC FF	isolate from ground motion at high frequencies and act at low frequency	Sensitive to perturbations?



Pre-isolator



MB quad stab:
active rigid

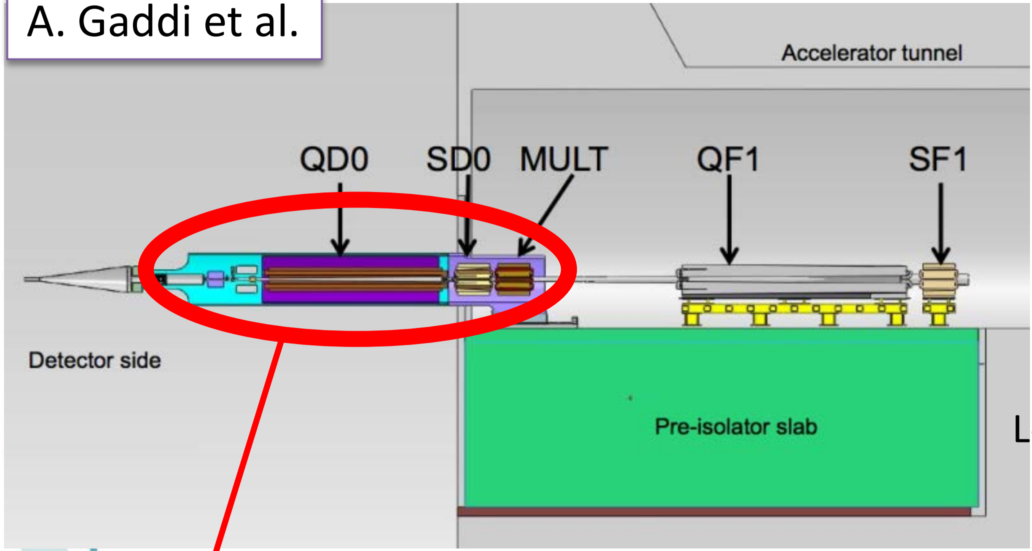


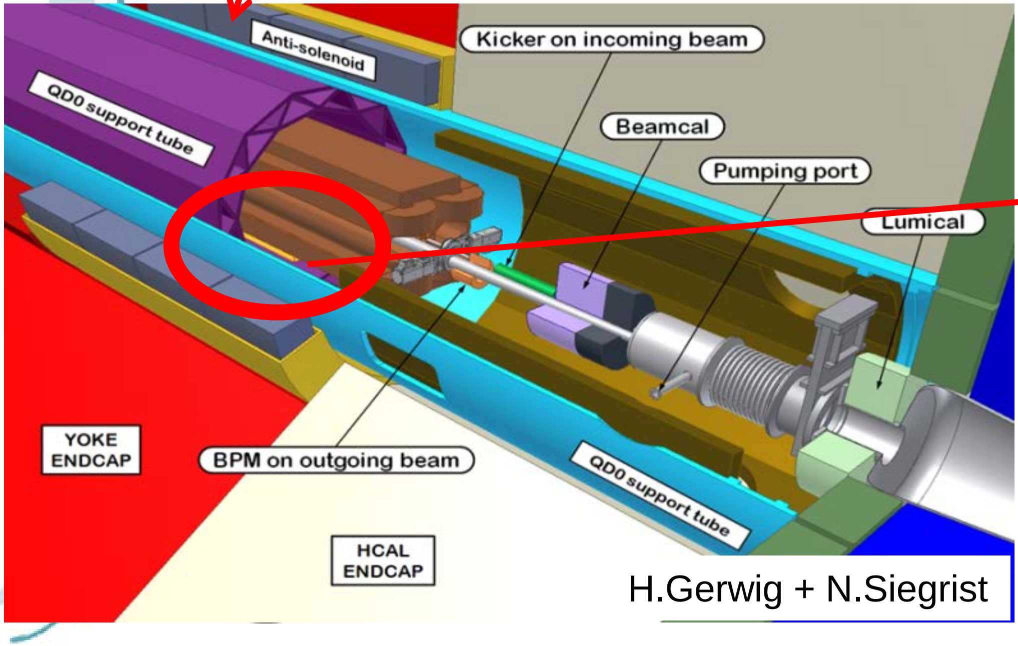
ATF2 FD

Stacis

Passive and active solution

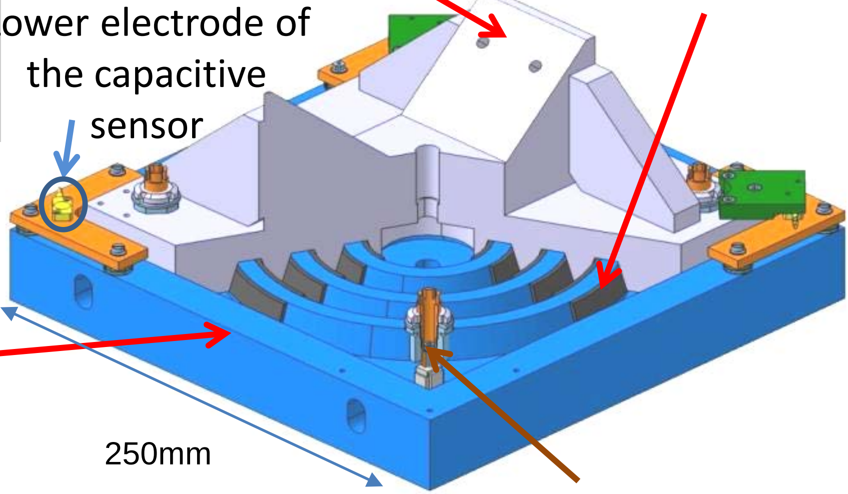
A. Gaddi et al.





H.Gerwig + N.Siegrist

Add coherence between QD0 and QF1 and reduce band-width on which active stabilisation has to act



V-support for the magnet

Elastomeric strips for guidance

Lower electrode of the capacitive sensor

Piezoelectric actuator below its micrometric screw

Additional passive stage directly under active system is also envisaged

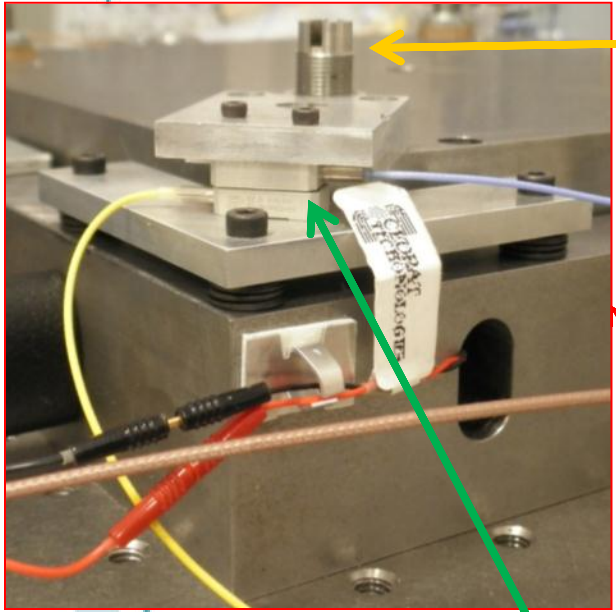
Very tough working conditions

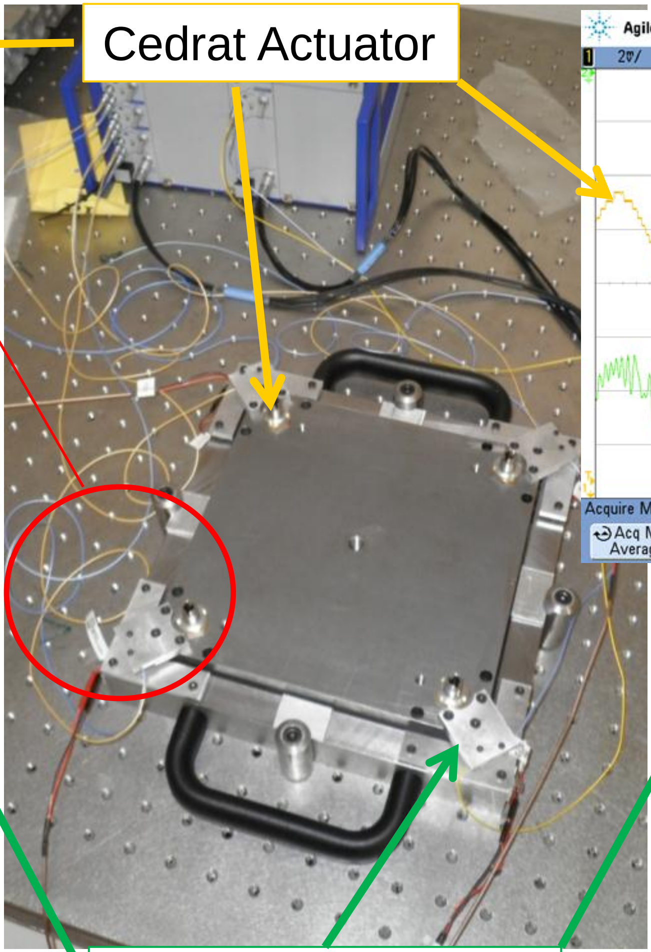
Tentative assembly of values from publications and CDR

- QD0 weight: 1500kg (coils excluded)
- QD0 length: 2.7m
- Electromagnetic average dose: 2.7.10^3 Gy/year (larger near outgoing pipe)
- Upper limit neutron dose: 50 Gy/yr.
- Average field (with anti-solenoid) : negligible

For the moment, working on proof of principle, although keeping these “accelerator” criteria in mind

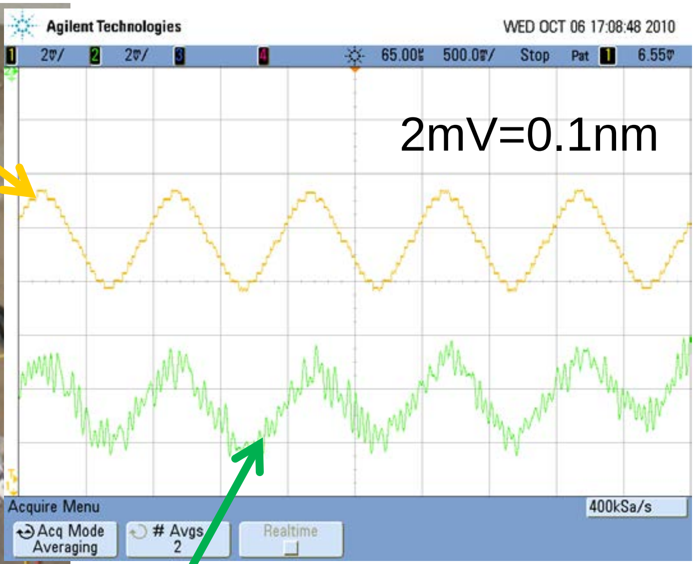
Stabilisation system





Cedrat Actuator

PI capacitive sensor

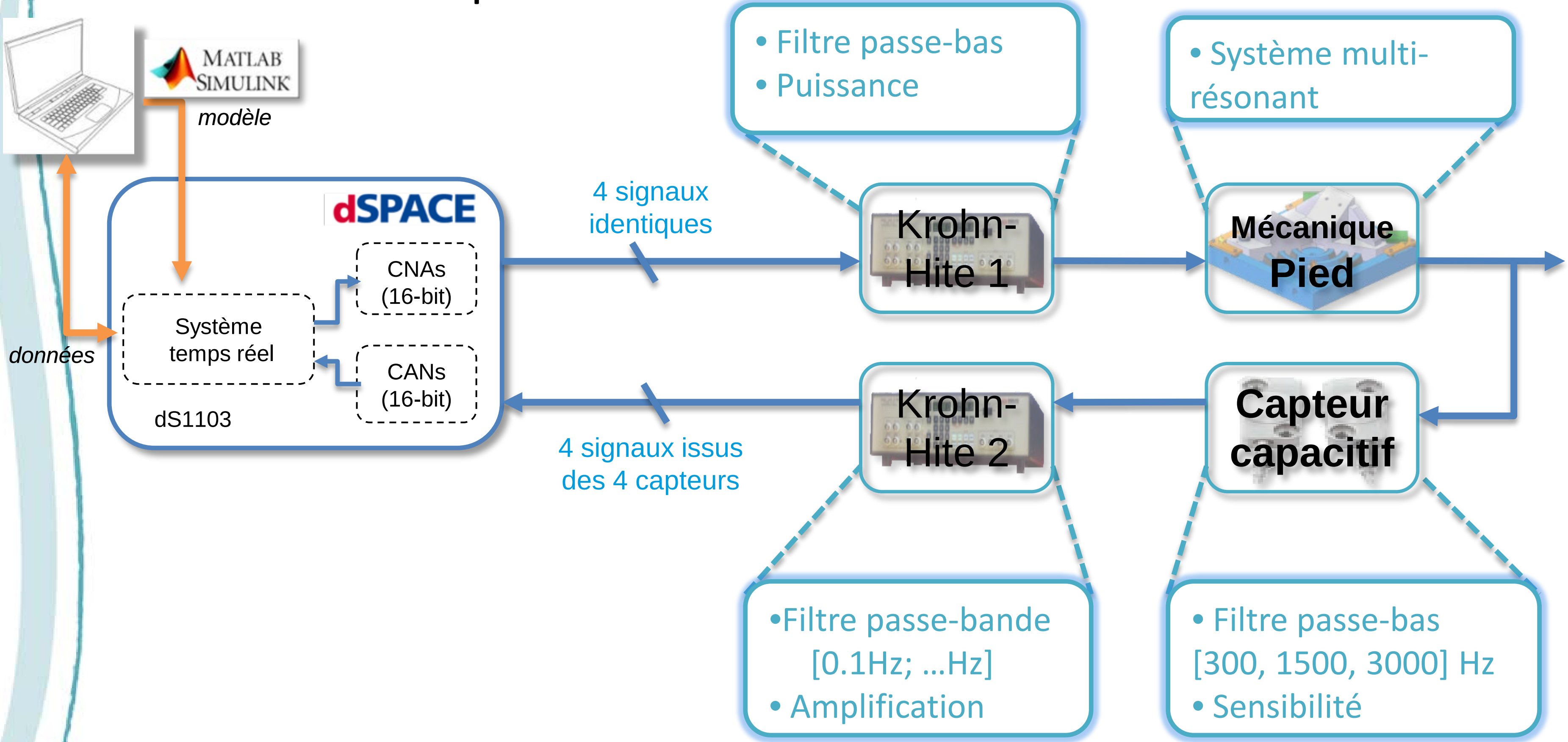


2mV=0.1nm

Instrumentation and dSPACE real time system adequate for nm control

Real time set-up

- Main components



- Filtre passe-bas
- Puissance

- Système multi-résonant

MATLAB SIMULINK

modèle

données

dSPACE

Système temps réel

CNAs (16-bit)

CANs (16-bit)

dS1103

4 signaux identiques

4 signaux issus des 4 capteurs

Krohn-Hite 1

Mécanique Pied

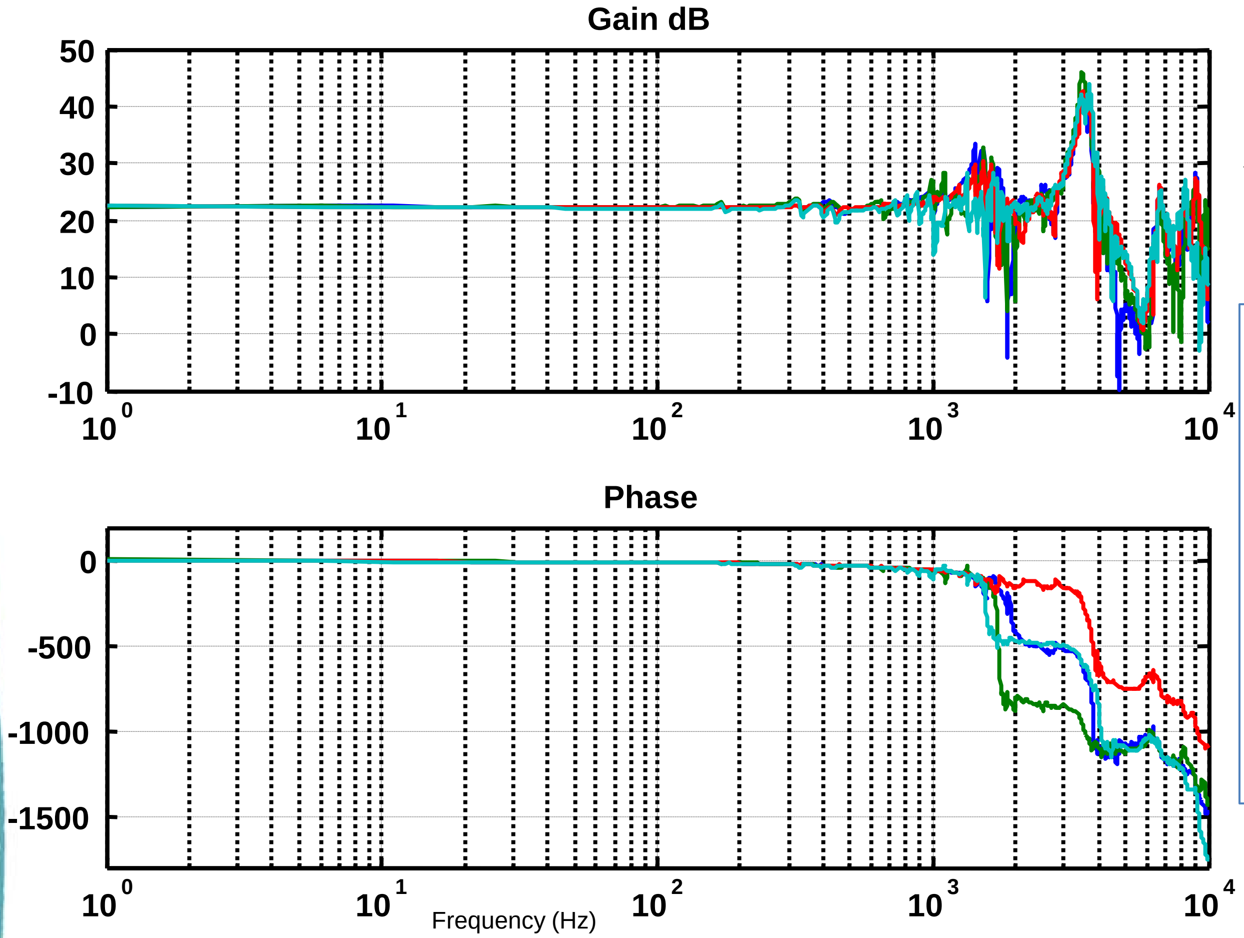
Krohn-Hite 2

Capteur capacitif

- Filtre passe-bande [0.1Hz; …Hz]
- Amplification

- Filtre passe-bas [300, 1500, 3000] Hz
- Sensibilité

Phase 1 : Stabilisation system behaviour

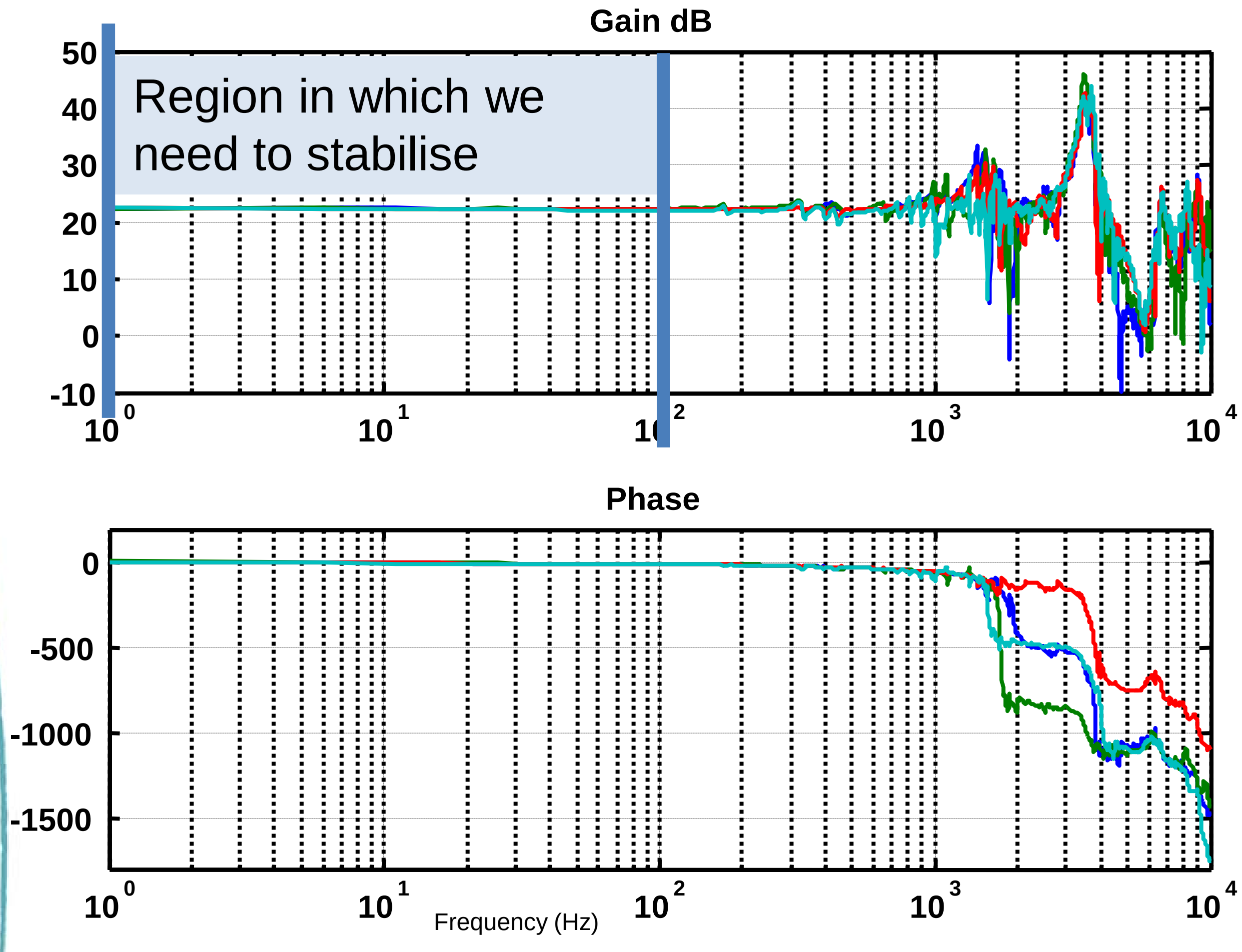


Signal on all 4 capacitive sensors without weight on system

Even after mounting and dismounting capacitive sensors and adjusting : the signals are always within 5% => very robust to installation changes

Further mechanical adjustment and correct signal filtering, the differences between sensors goes down to 1.2%

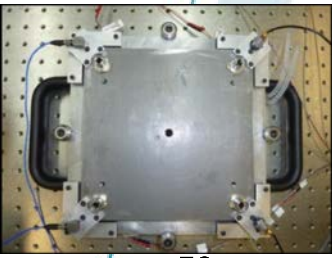
Phase 1 : Stabilisation system behaviour



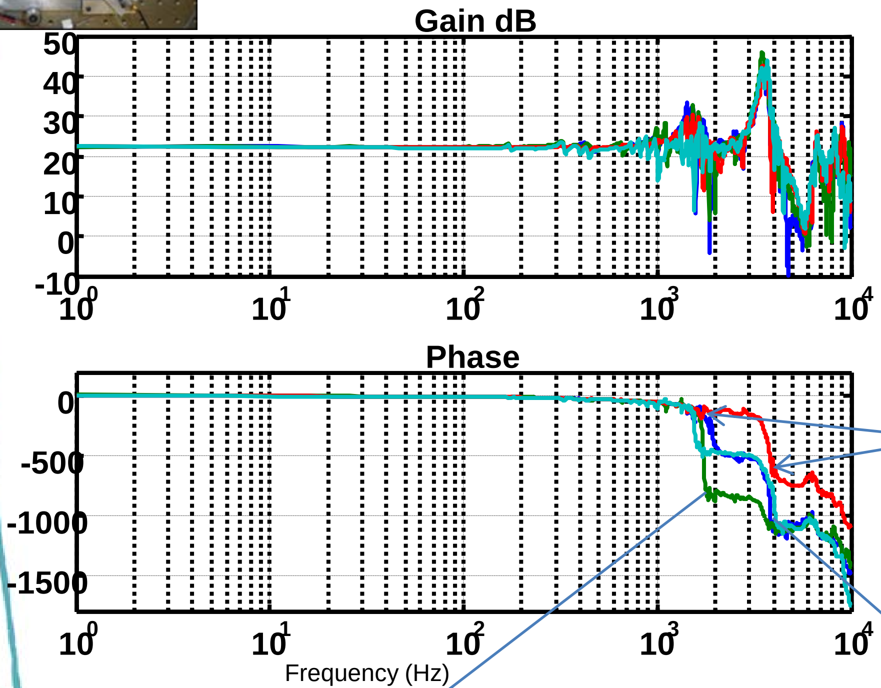
Region in which we need to stabilise

Signal on all 4 capacitive sensors without weight on system

No parasitic peak in frequency region of interest for QD0 stabilisation

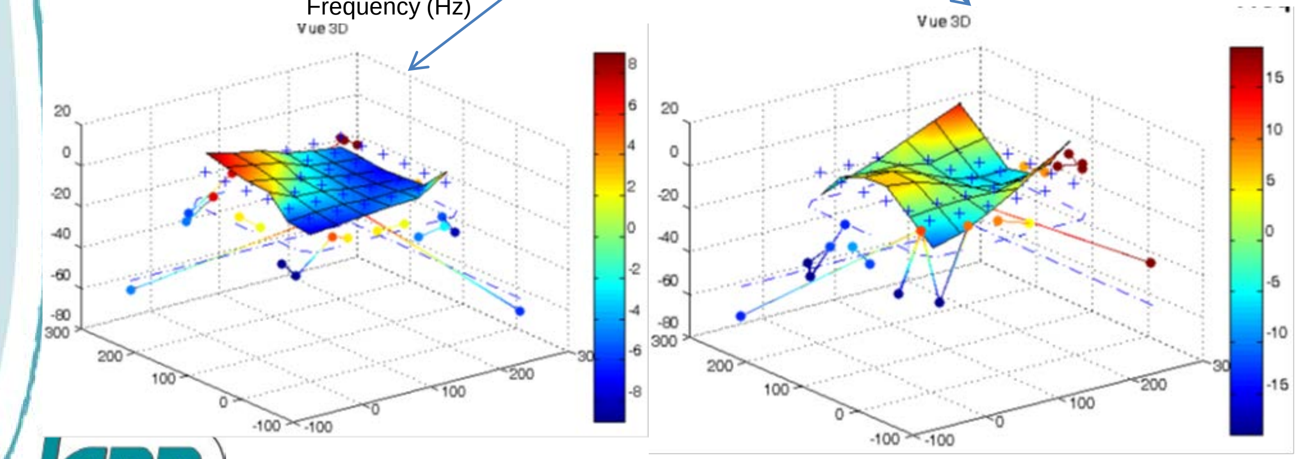


Phase 1 : Stabilisation system behaviour

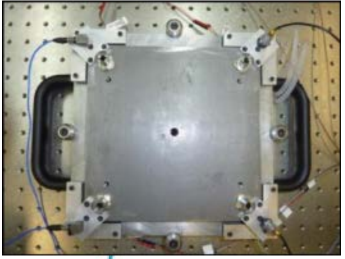


Signal on all 4 capacitive sensors without weight on system

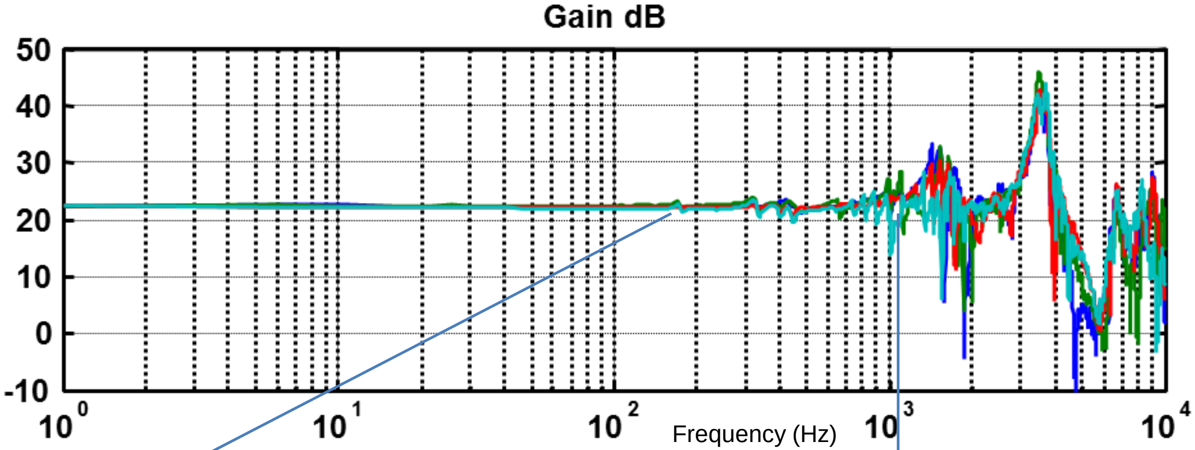
Intrinsic resonances if change of phase by 90°: other peaks just from boundary conditions
=> 2 resonance peaks just below 2kHz and near 4kHz.

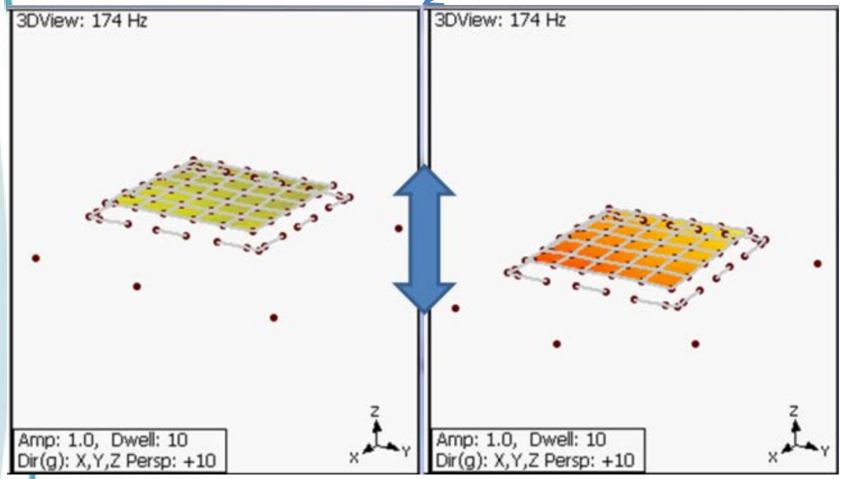


First intrinsic resonance frequency near 2kHz : experimental and theoretical values agree.



Other modes due to boundary conditions



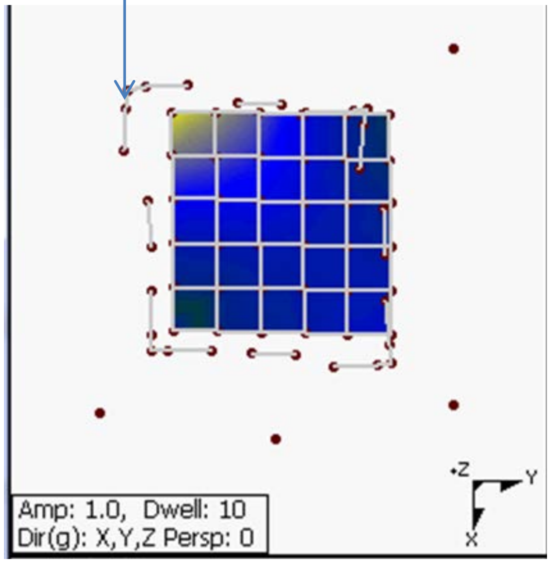

3DView: 174 Hz

Amp: 1.0, Dwell: 10
Dir(g): X,Y,Z Persp: +10

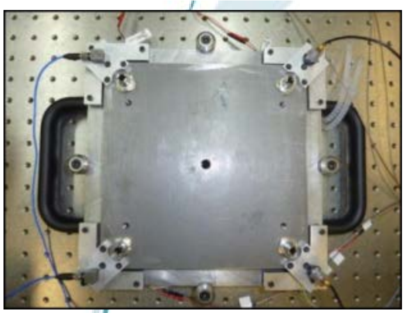
3DView: 174 Hz

Amp: 1.0, Dwell: 10
Dir(g): X,Y,Z Persp: +10

« jumping » mode due to table

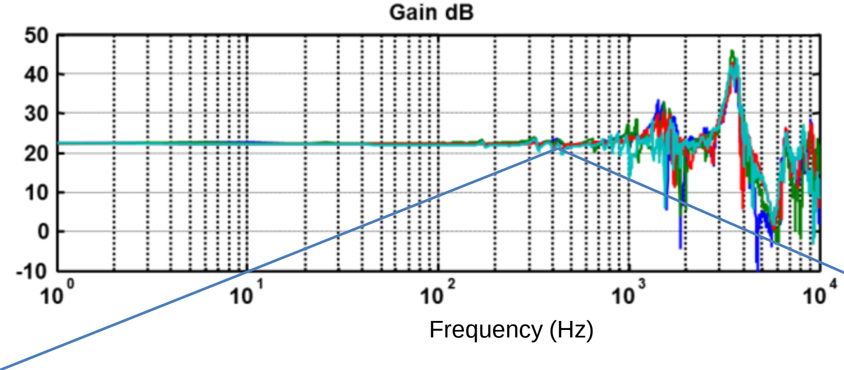

Amp: 1.0, Dwell: 10
Dir(g): X,Y,Z Persp: 0

Capacitive sensor support needs study

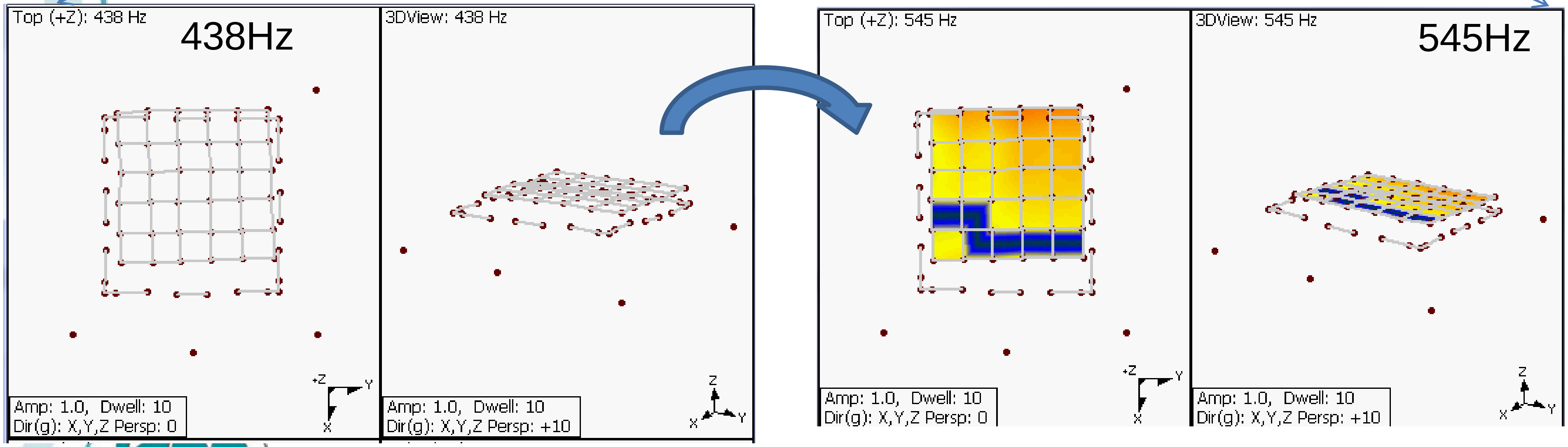


Other modes due to boundary conditions

“sliding” mode



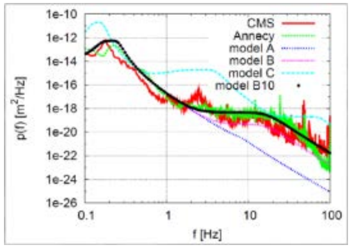
- changing to new elastomer (better guidance)
- changing some system parameters

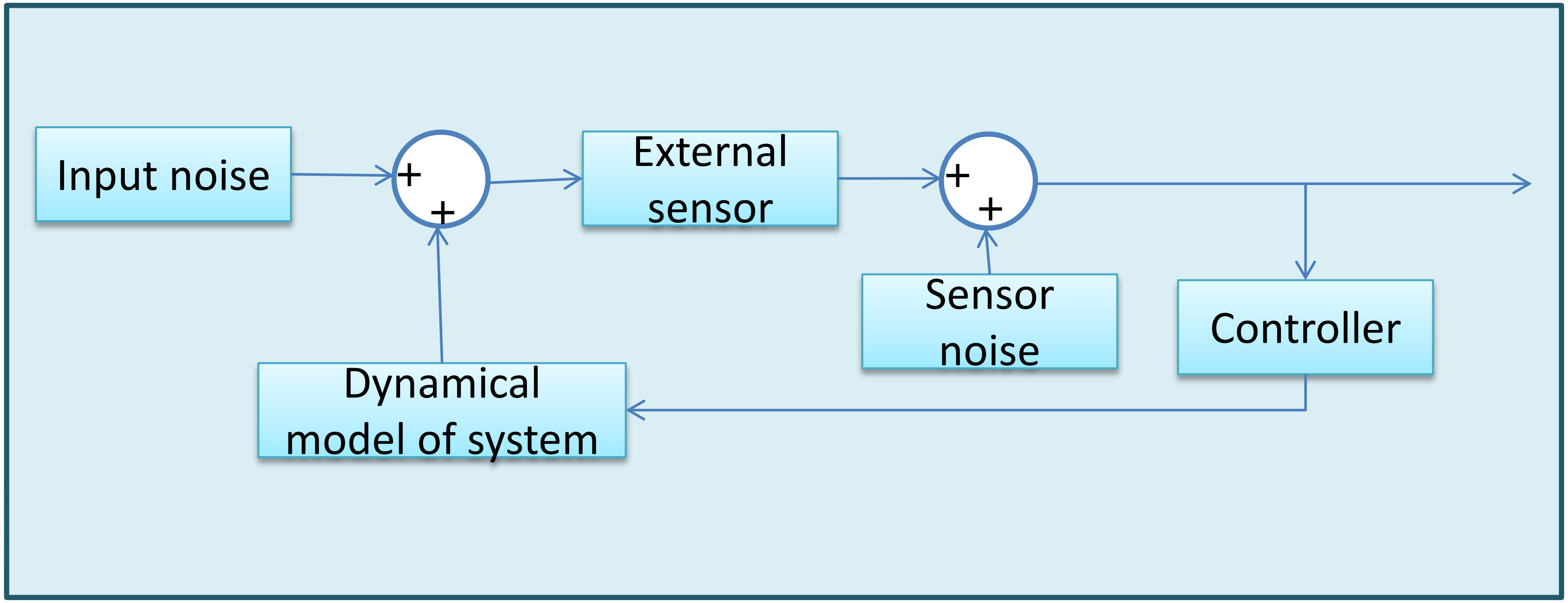


Phase 1 concluded

- Sensor installation robust to multiple mounting and dismounting
- Very good mechanical behaviour with no resonance peak in region of interest
- Signal filtering under control

Correction scheme





Input noise

External sensor

Sensor noise

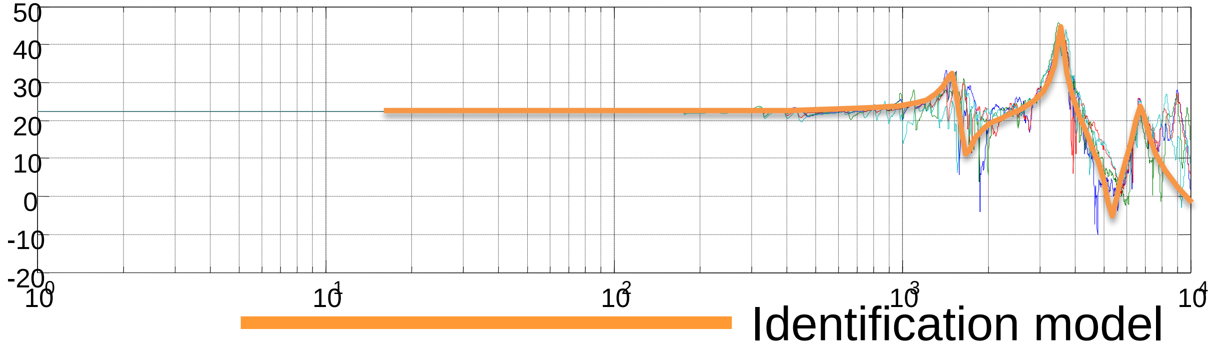
Controller

Dynamical model of system

Dynamical model of system

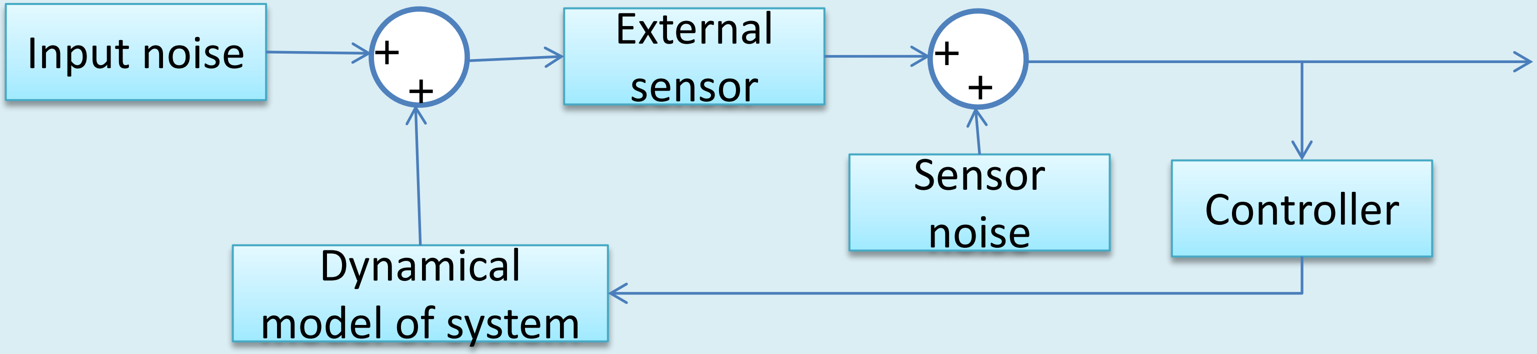
- Find a model describing the system
  - Find a numerical filter that does not change the phase (but in our case, the peaks are not noise related)
  - A sum of three 2nd order modes describes the peaks
  - Adding a pure delay from acquisition system and sensor describes the phase

Phase 2: system identification



A model describing the system has been identified: phase 2 almost finished, need to confirm the model for different I/O

Correction scheme : simulations ongoing with promising results


Input noise

External sensor

Sensor noise

Controller

Dynamical model of system

Next steps for stabilisation system

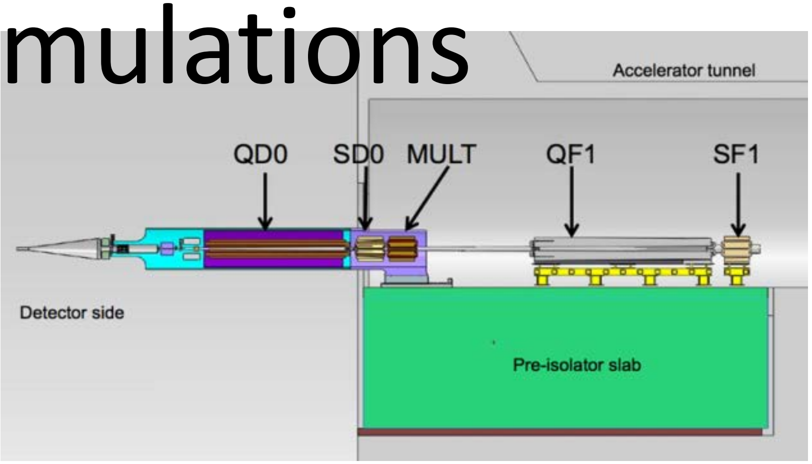
- Implement controller on stabilisation system (go from simulations to measurements)
- Start again with a QD0 « dummy » mass

Complementary study

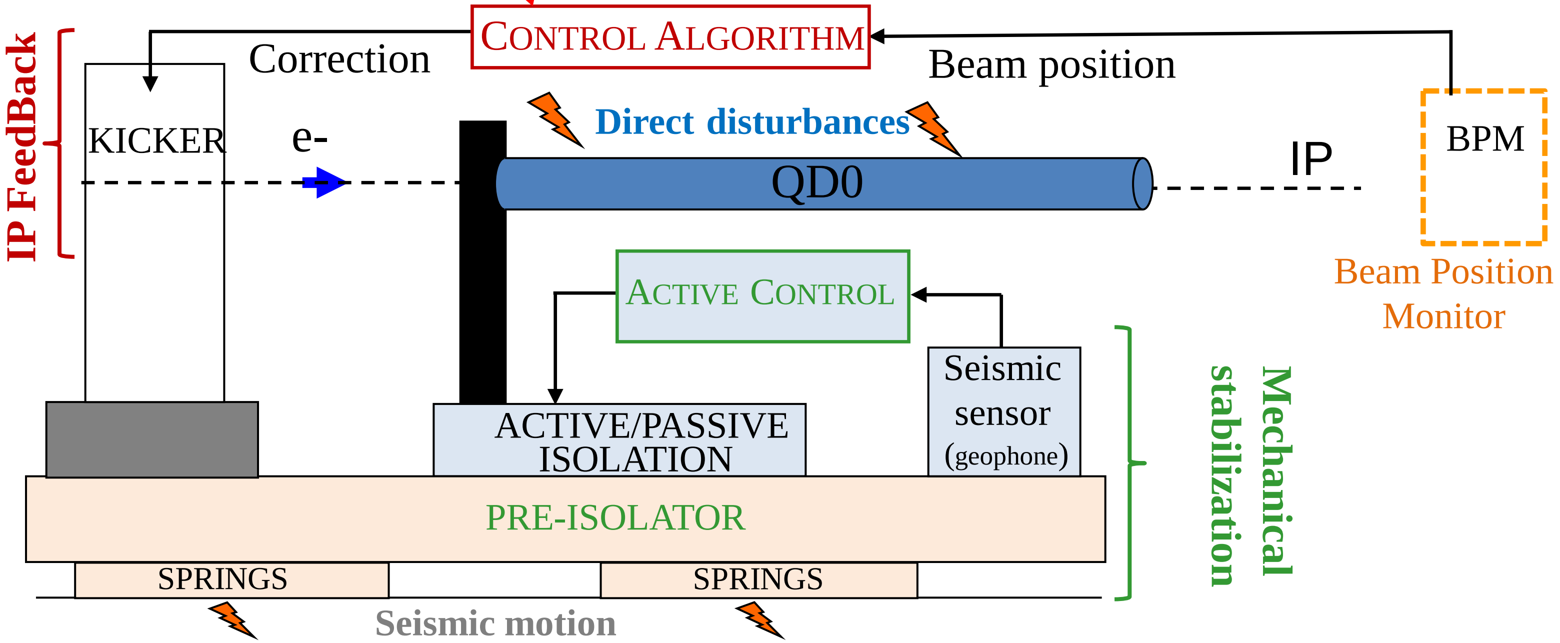
- Mechanical stabilisation under study but

- Need to get a feeling on the impact of the combined different jitter mitigation systems
- Study of a complementary IP feedback <u>working at CLIC rate of 50Hz </u>aiming at an integrated rms of 0,15nm at 0,1Hz.

LAViSta IP feedback design and integrated simulations



Characteristic feature:
non-linear approach



IP FeedBack

CONTROL ALGORITHM

Correction

Beam position

KICKER

e-

Direct disturbances

QD0

IP

BPM

Beam Position
Monitor

ACTIVE CONTROL

Seismic
sensor
(geophone)

ACTIVE/PASSIVE
ISOLATION

PRE-ISOLATOR

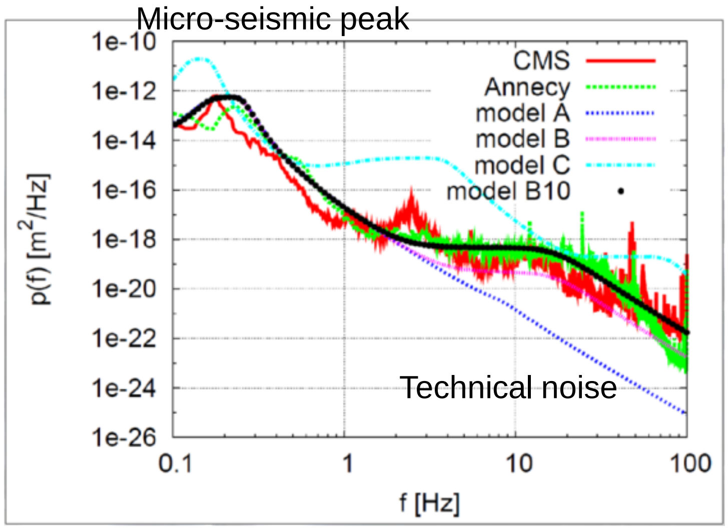
SPRINGS

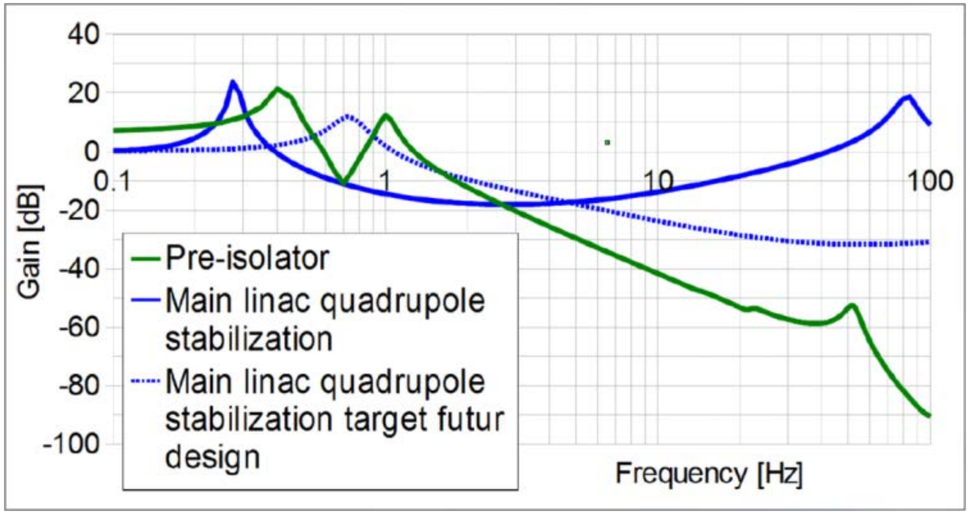
SPRINGS

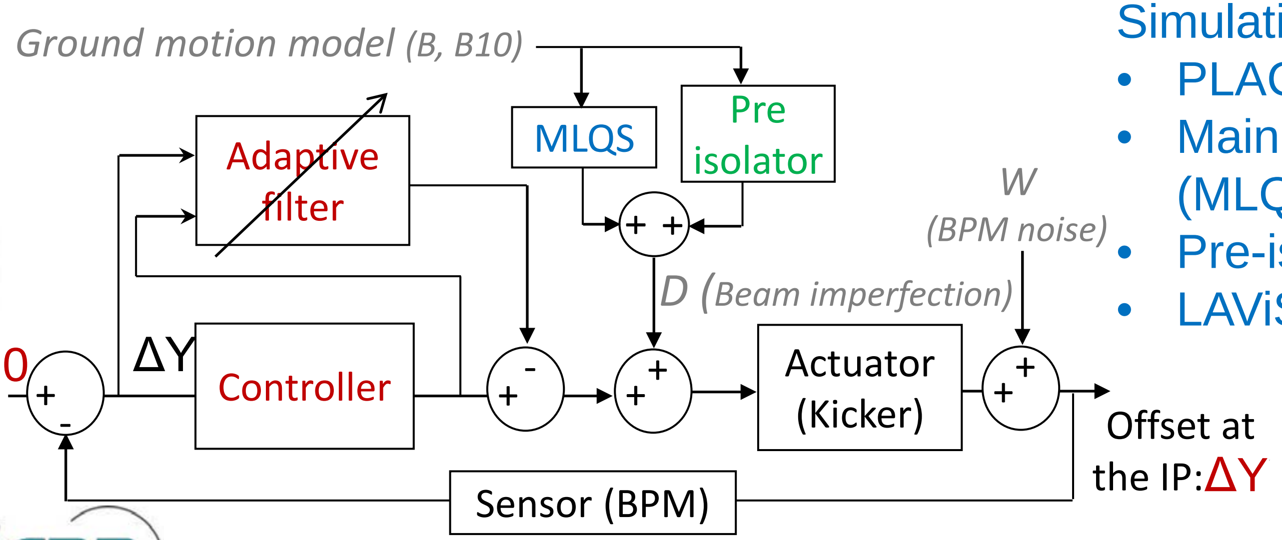
Seismic motion

Mechanical stabilization

This is what is implemented







Ground motion model (B, B10)

MLQS

Pre isolator

Adaptive filter

W (BPM noise)

D (Beam imperfection)

0

ΔY

Controller

Actuator (Kicker)

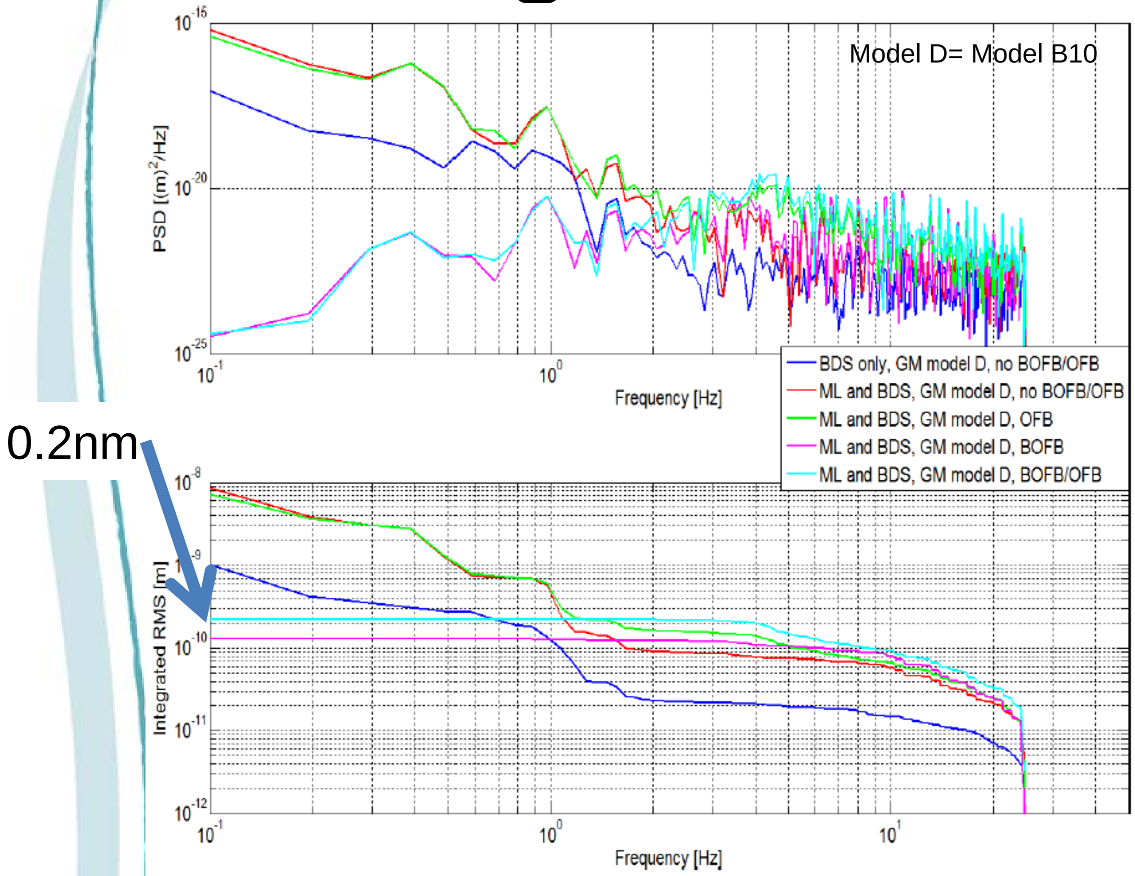
Offset at the IP: ΔY

Sensor (BPM)

Simulations done with

- PLACET and Guinea-Pig
- Main Linac Quad Stab (MLQS)
- Pre-isolator
- LAViSta IPFB control

Integrated simulation for IPFB



0.2nm

-only BDS and pre-isolator

-adding Main linac + MLQS, no FB

-adding LAViSta-IPFB (BOFB) + OFB

-see effect of pre-isolator: reduce rms at high frequencies but peak around 1Hz

-increases rms at high frequency=> ML beam jitter other than GM

-LAViSta-IPFB reduces rms by factor 45 at 0,1Hz to a sub-nm level

=> need a good beam at FF entrance for good performance

Conclusion

- Not one single system will get CLIC to the desired beam stability and luminosity
- Need to combine Main Linac Stabilisation, BDS optimisation, Beam-based feedback, IP feedbacks etc… And each one has to do it's best in it's band-width and make sure one does not destroy the work of others

  => integrated studies essential!
- QD0 stabilisation system mechanically and instrumentally good: need to add feedback (2011) and QD0 mass (2012)
- LAViSta IP feedback reduces rms at 0,1Hz by a factor 45 to 0.2nm => integrate future "measured" FF stabilisation