Integrated simulations

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Outline

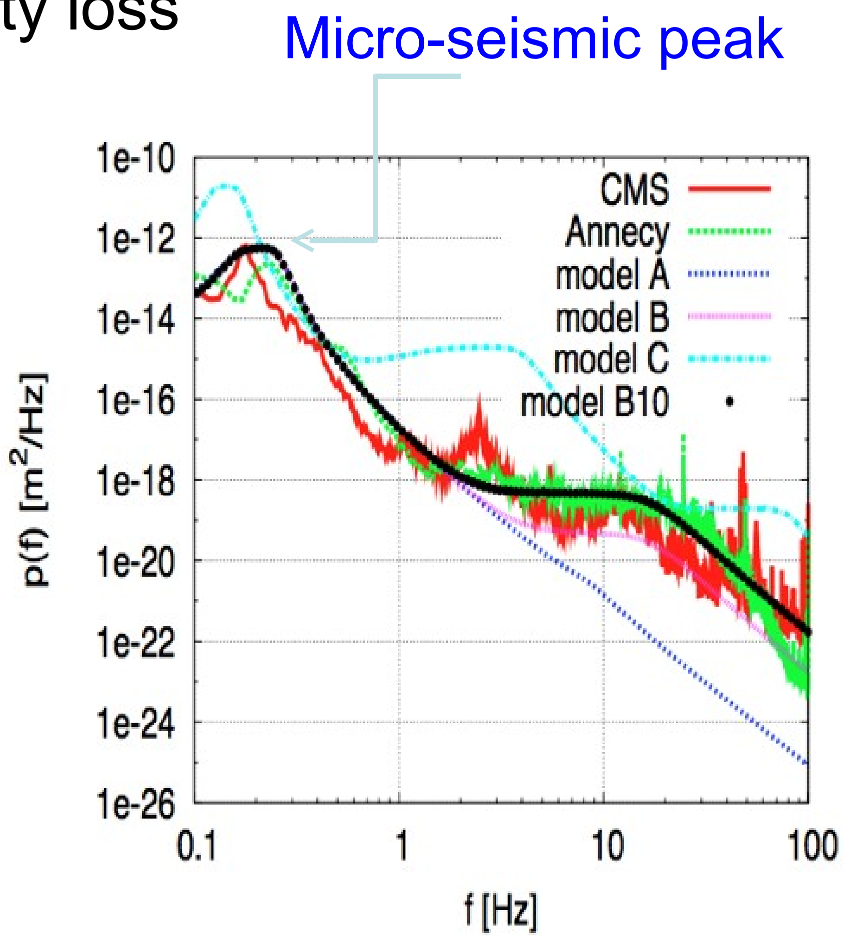
1. Introduction
   - Ground Motion
   - Stabilization & Feedback systems
   - Framework

2. Dynamic simulations
3. Conclusions

1. Introduction

Ground Motion

- Main dynamic cause for luminosity loss
- Slowly drifting element positions
- Short time scales (< 10 s)
  - A. Seryi models [1] (see fig
- Long time scales
  - ATL law:
  - $\langle(\Delta y)^2\rangle = A*t*L$
- Model A, B and B10 used

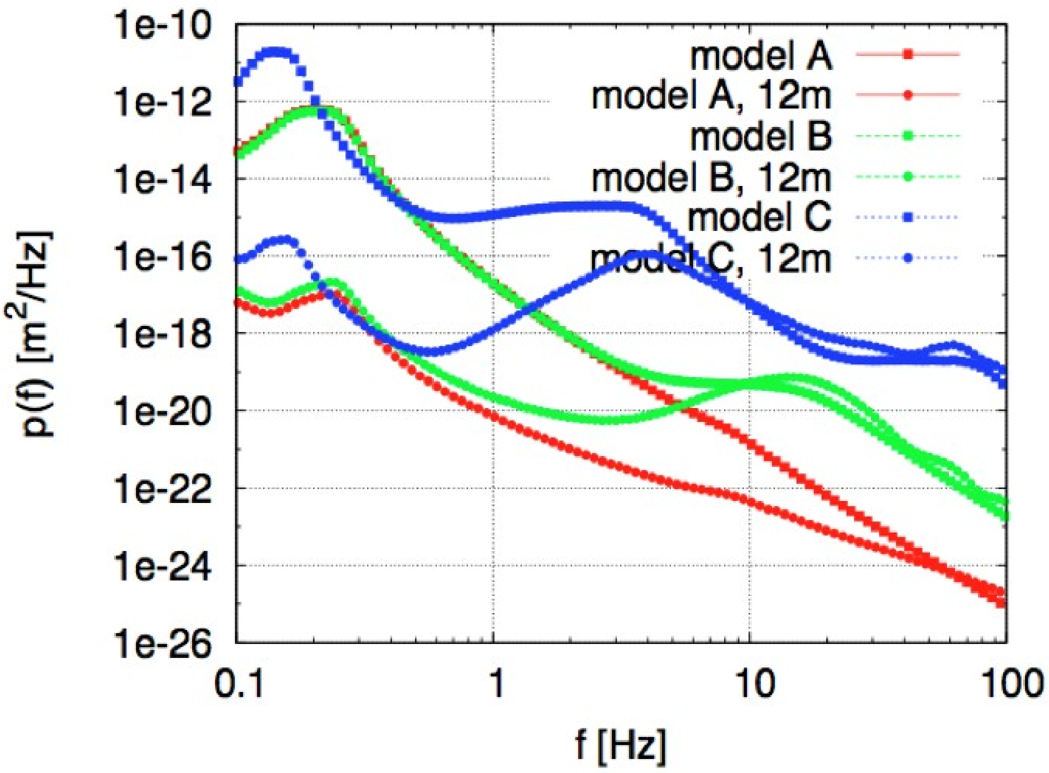


Ground Motion

Ground Motion Correlation

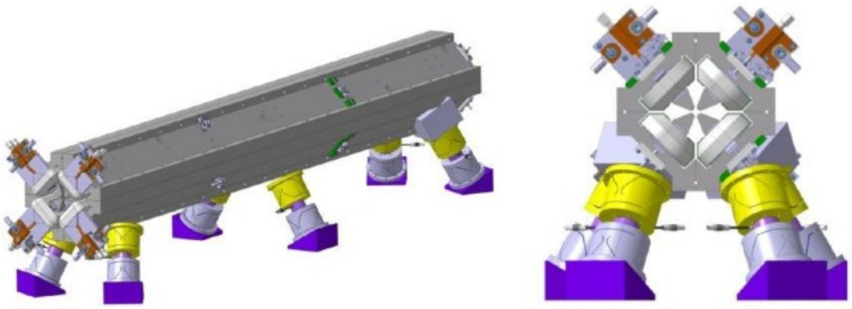
- Ground motion is correlated
- Correlation has an impact on the luminosity performance
  - e.g. relative offsets of final quadrupoles is important (relevant distance $\approx 12\,\mathrm{m}$)

$\Rightarrow$ high frequency part is uncorrelated

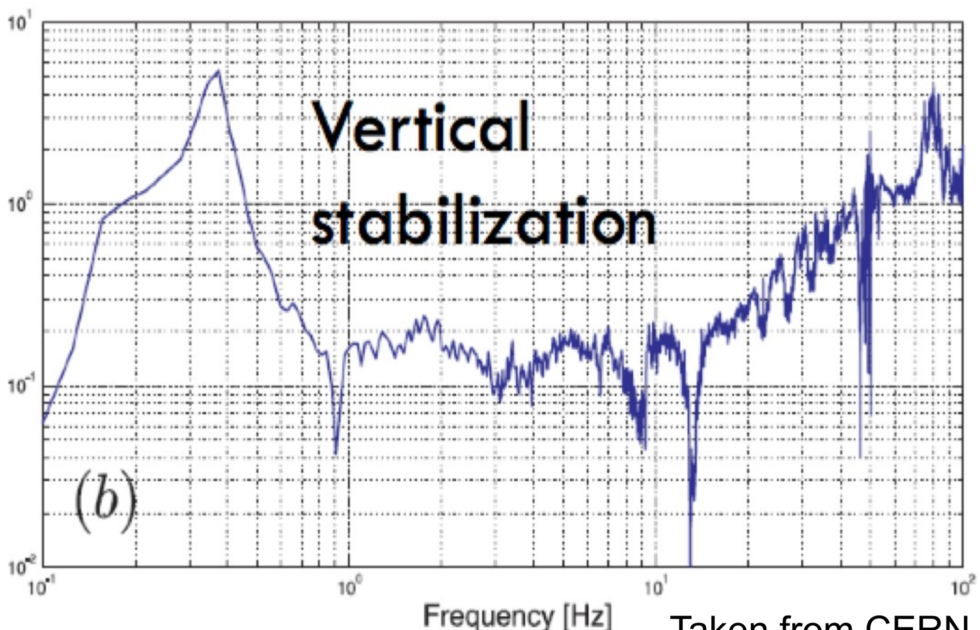


Taken from D. Schulte

Quadrupole Stabilisation



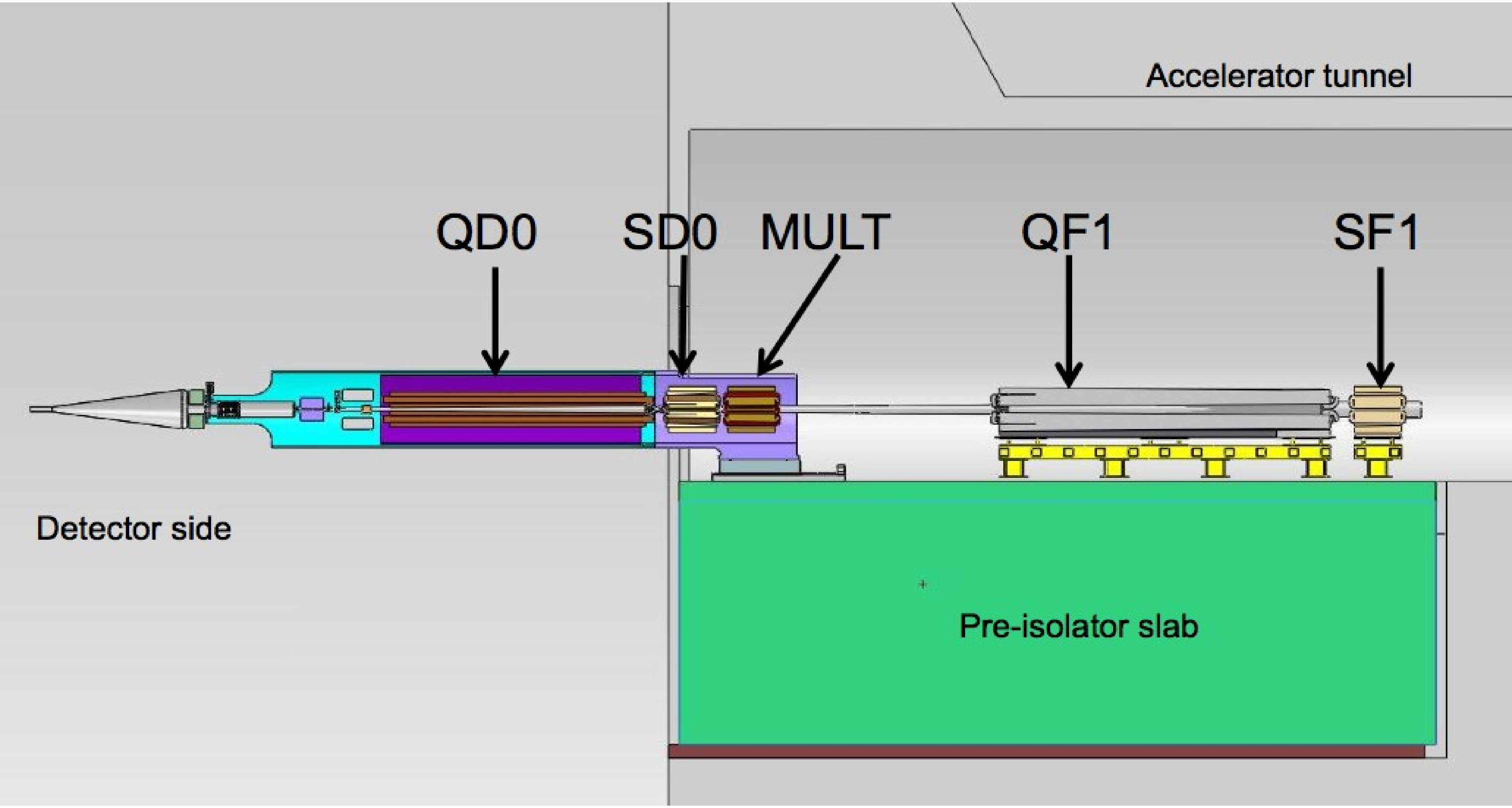
- Reduces quad movements above 1 Hz
  - (int. rms 1 nm)
- Reduces emittance growth and beam jitter for high frequencies



Taken from CERN stabilisation group (see [2])

Pre-isolator

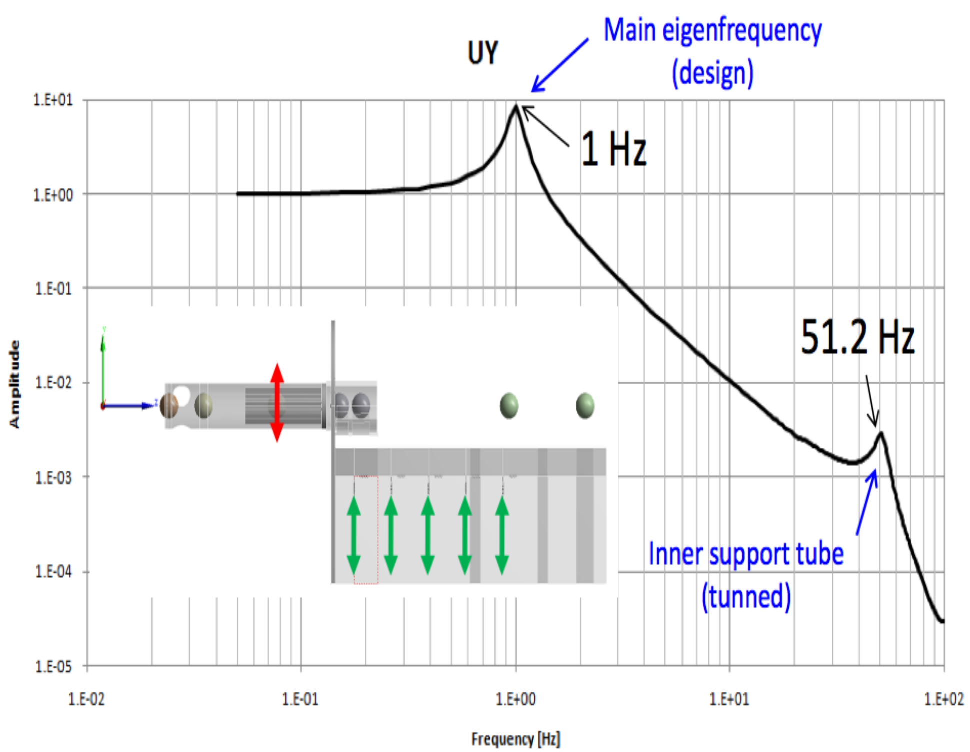
Taken from A. Gaddi et al. (see [3])



Pre-isolator

Harmonic excitation in the vertical direction

Vertical steady-state response at QD0



Reduces movements of the Final Focus magnets above several Hz

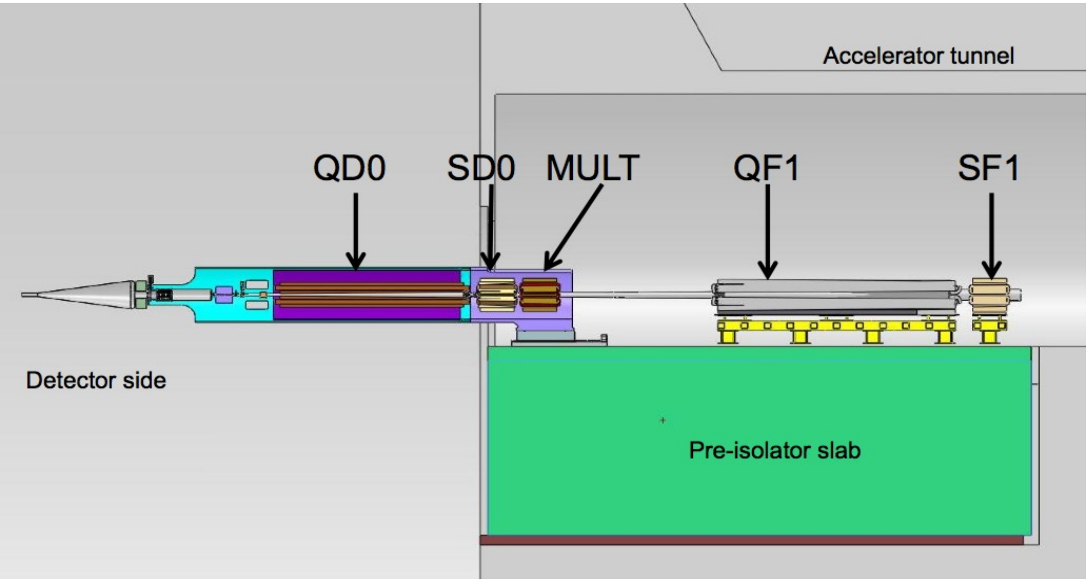
(int. rms 0.13 nm)

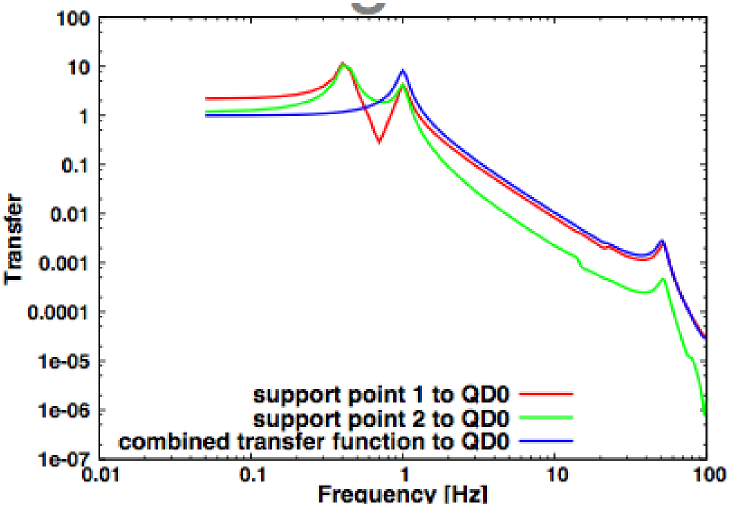
Reduces beam jitter (offset) at IP for high frequencies

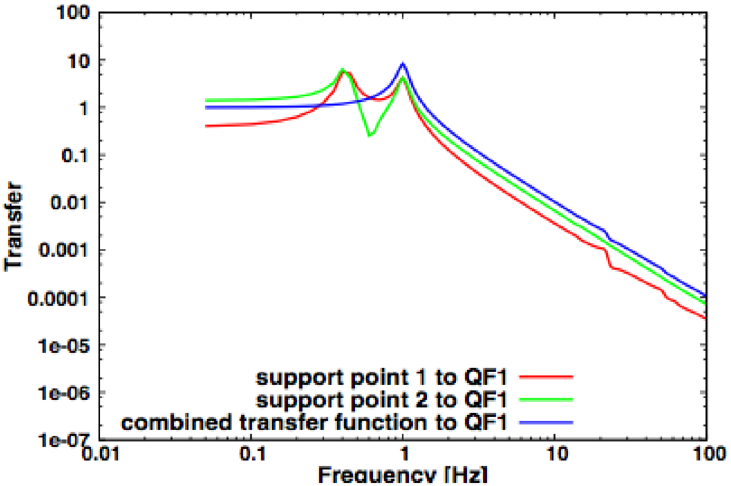
Preisolator

Preisolator tilt is included

- 4 different transfer functions
- Tilts/resonances at 0.4 - 1 Hz and 50 Hz







Beam-based feedback

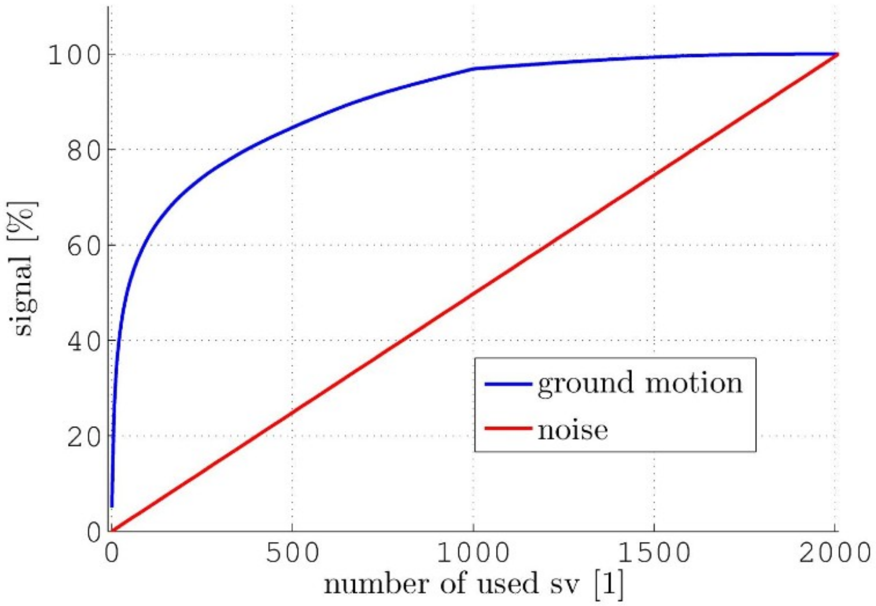
Orbit correction

2010 quads and BPMs per beamline

Weighted SVD controller [4]

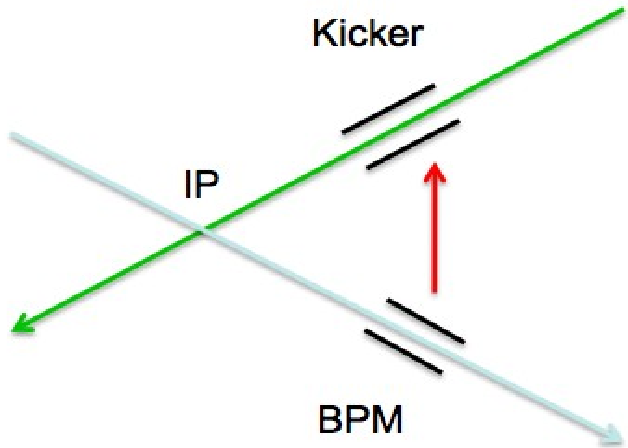
- One large response matrix
- Smaller singular values downweighted
- Adapted to ground motion and stabilisation transfer functions
- For details, see presentations in Beam Physics meetings

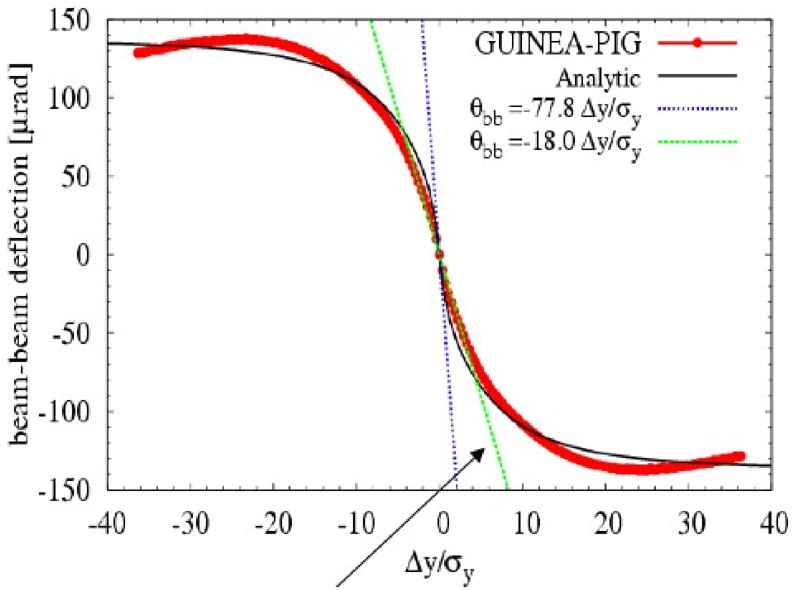
Robust against noise



Reduces emittance growth for low frequencies

IP feedback





- Feedback based on the deflection angle of the colliding beams
- Pulse to pulse (intrapulse possible, but not used here)
- Reduces beam offset at IP for low frequencies
- Non-linear effect
- In collaboration with LAPP-Annecy

Taken from J. Resta-Lopez (see also e.g. [5])

Simulation Framework & Settings

A simulation framework has been setup

- Placet-CVS: /clic-integrated-simulations/linac-bds/dynamic
- Main Linac and BDS, Placet for tracking
- GuineaPig for luminosity calculation

Ground motion generation for all models

Including all feedback systems and versions

One settings file

Scripts to run on batch and analyse results

In continuing development, more will be added

2. Simulations (CDR status)

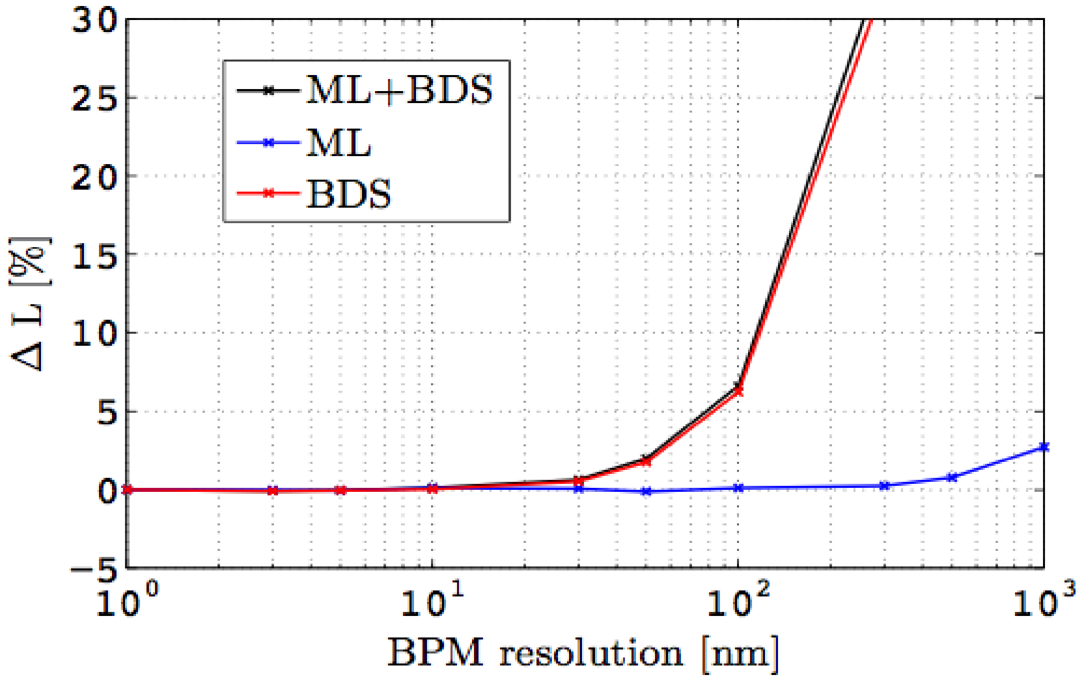
BPM resolution

Impact of BPM resolution

No ground motion, only BPM errors

Required BPM resolution in BDS 50 nm (baseline) for a few % loss

Improved result due to noise-robust beam based feedback

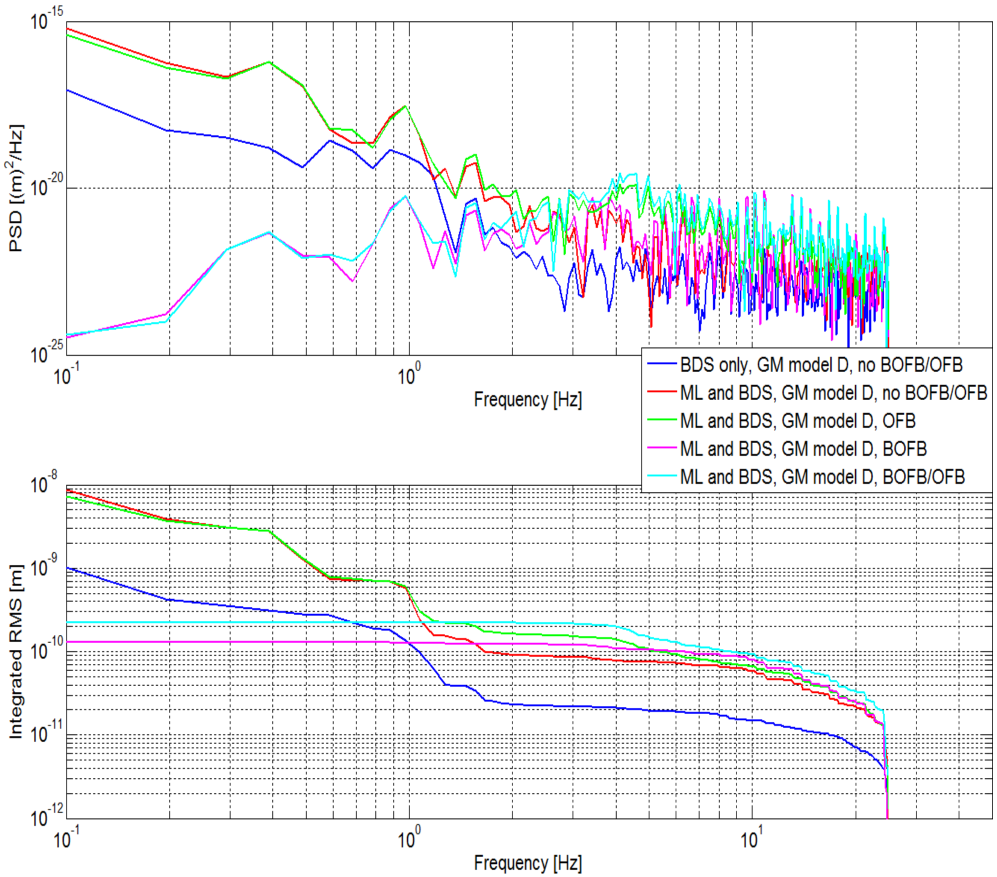


IP Feedback Controller (LAPP)

Optimised IP Feedback controller by LAPP-Annecy et al. [5]

Integrated in full simulations

RMS beam motion at IP about 0.2 nm (till 0.1Hz)



Static imperfection treatment

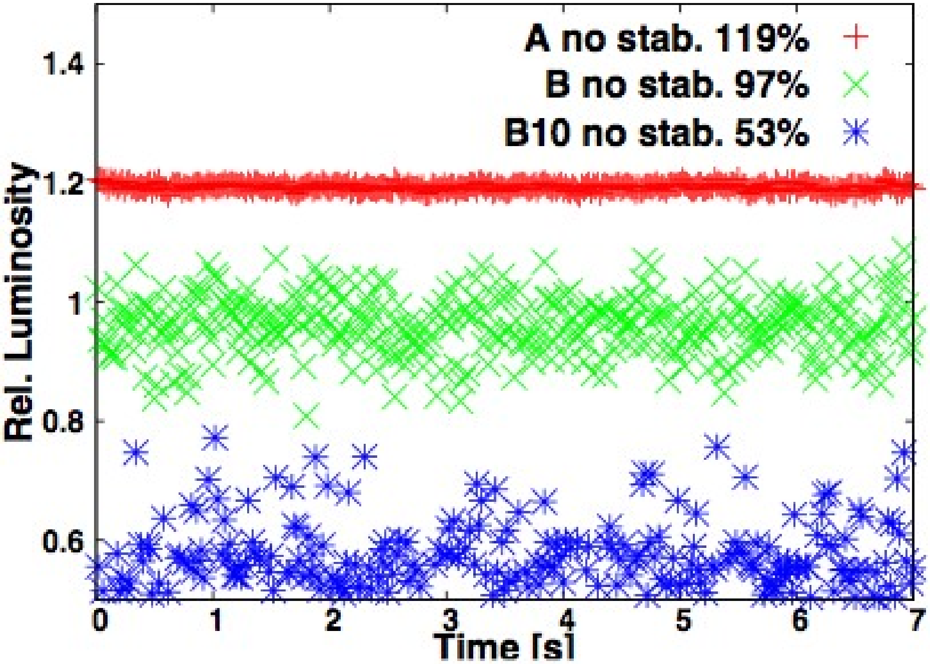
- The rel. peak luminosity is calculated wrt the nominal peak luminosity of $2*10^{34}$ $cm^{-2}s^{-1}$
- Static imperfections have been accounted for by a 20nm vertical emittance at the ML start
- Dynamic imperfection budget is about 20% (so perfect beamline = 120%)

Results - no local stab.

- Model A:

  no stab. needed

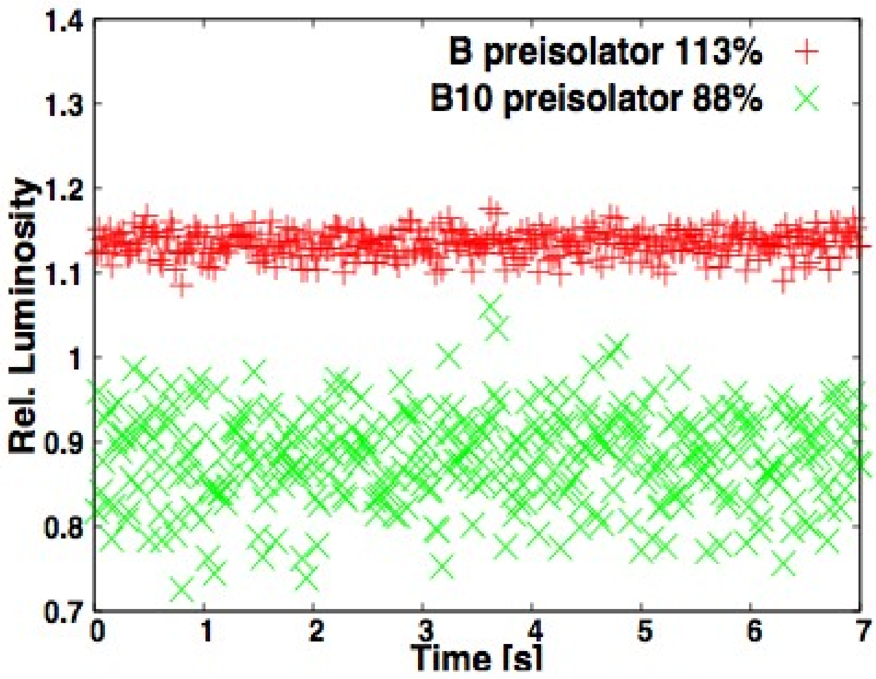
Averaged over 20 seeds



Results - FD stab.

- Model A:
  no stab. needed
- Model B:
  needs FD stab.

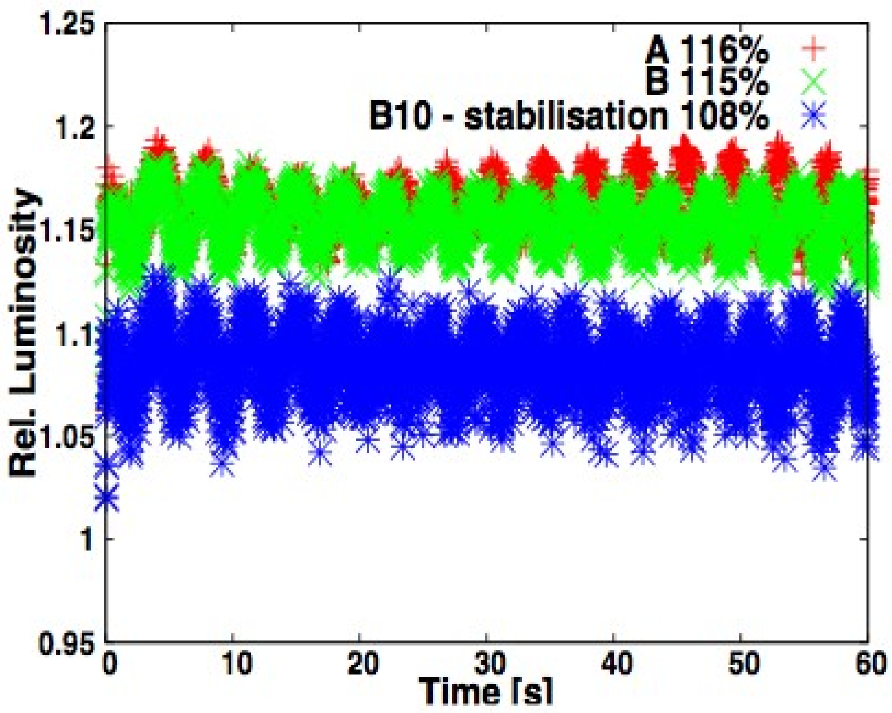
Averaged over 20 seeds



Results - FD + Quad. stab.

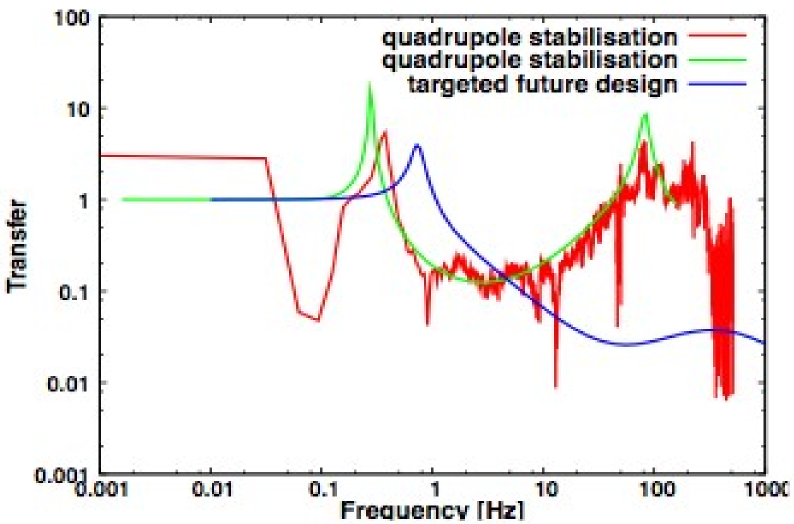
- Model A:
  - no stab. needed
  - (got worse!)
- Model B:
  - needs FD stab.
- Model B10 or worse:
  - needs quad stab.

Averaged over 20 seeds

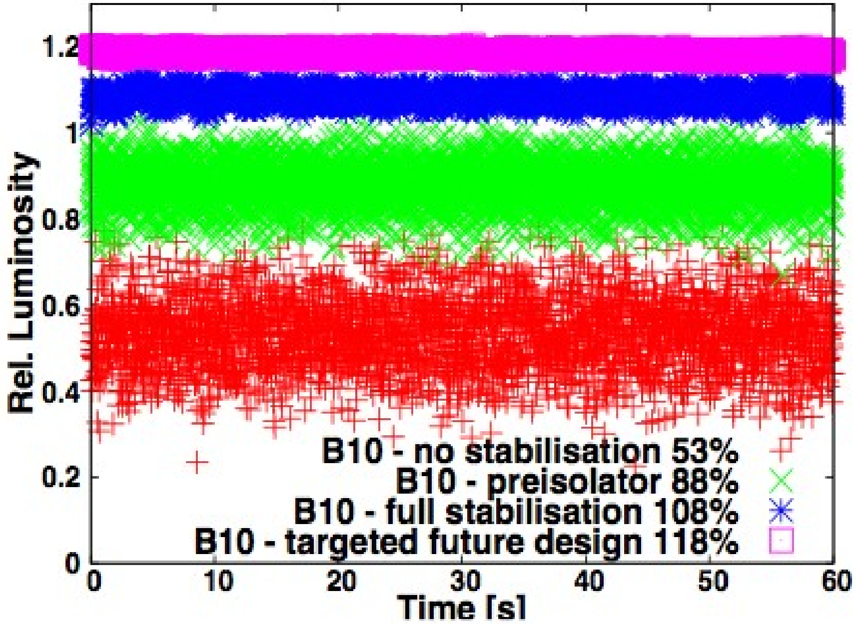


Results - possible future design of QP stab.

- Possible future design, very promising
- Other dynamic effects will overtake



Averaged over 20 seeds



3. Conclusions

Conclusions

- A simulation framework for ground motion effects in CLIC was developed.
- It is used:
  1. as a test bench for algorithm design and optimization.
  2. to verify the allover luminosity preservation in spite of ground motion (feasibility item for the CDR)

- The simulations delivered guidelines for the design of the stabilization system transfer function:
  1. TF should be 1, around the 0.1-0.4 Hz (micro-seismic peak)
  2. It should also be kept small in the frequency range around 75 Hz (amplification from the orbit FB).

- The final results are satisfactory for the CDR (an essential feasibility item for the CDR has been addressed)

Further information and references

[1] A. Seryi, “Ground Motion Models for Future Linear Colliders”, EPAC2000, Vienna

[2] C. Collette et al., “Active quadrupole stabilization for future linear particle colliders”, Nuclear Instrumentation and Methods in Physics Research A, 2010

[3] A. Gaddi et al., "Passive Isolation", IWLC 2010, Geneva

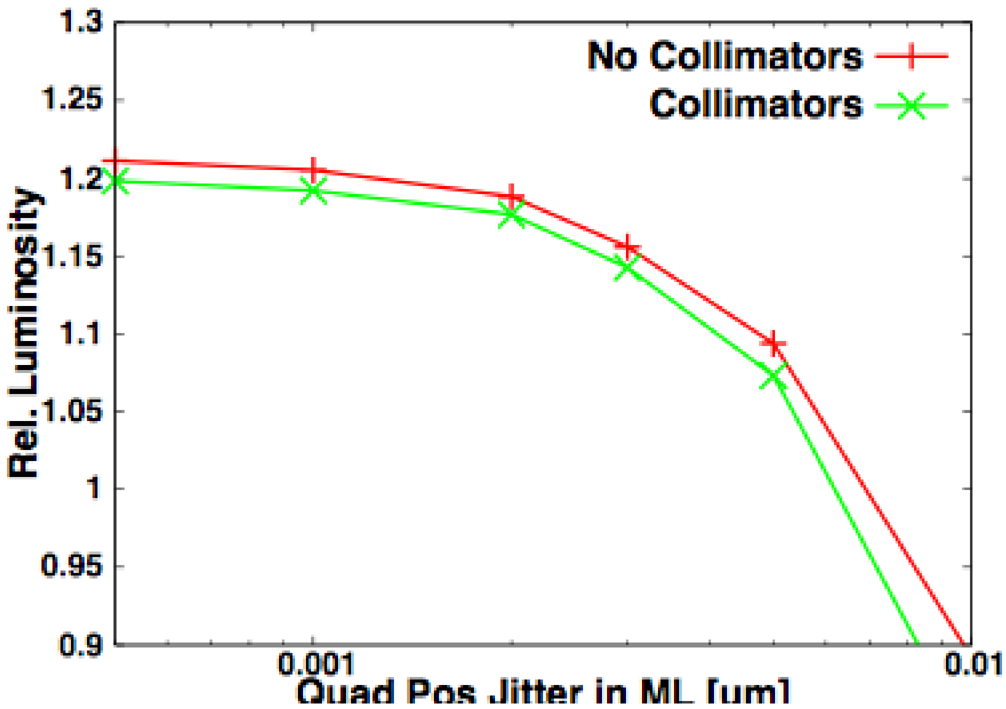
[4] J. Pfingstner et al., “SVD-based Filter Design for the Trajectory Feedback of CLIC”, IPAC 2011, San Sebastian

[5] G. Balik et al., "Interaction Point Feedback Design and Integrated Simulations to Stabilize the CLIC Final Focus", IPAC 2011, San Sebastian

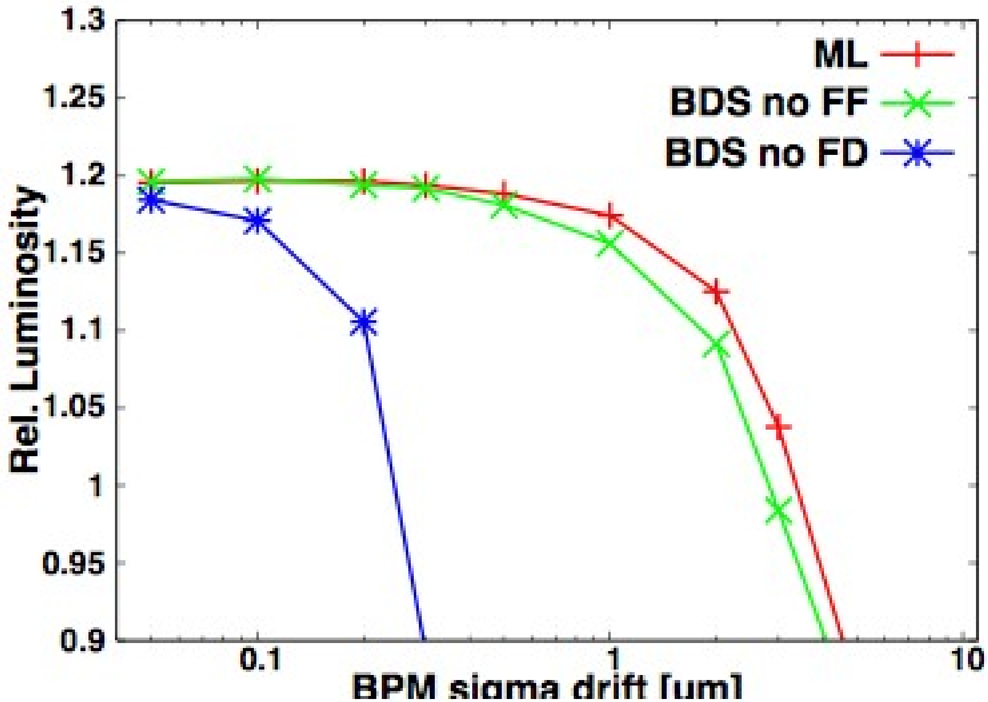
Thank you for your attention!

Backup: some robustness studies

Collimator influence



BPM drifts


1.3
1.25
1.2
1.15
1.1
1.05
1
0.95
0.9
Rel. Luminosity
0.1
1
10
BPM sigma drift [um]
ML
BDS no FF
BDS no FD

Quadrupole strength jitter