Vibrations studies for the nominal optics and the ultra-low beta optics

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Introduction

Relative motion tolerance between beam and IP: 10nm
(5% accuracy on beam size measurements)

✓ QDO/QF1FF: induce the most beam deflection at the IP when not perfectly aligned (ground motion)

➔ Studies of stabilization were focused on them

➔ Good ground motion (GM) coherence between QD0/QF1FF and IP

➔ Fixation to the floor: low relative motion between them

✓ Other ATF2 quadrupoles: lower beam deflection

➔ Fixed to the floor even if GM coherence is low (far from IP)

➔ New study: relative motion calculation between beam and IP due to the beam deflection induced by these quads subjected to GM

Usefulness of a stabilization for these quadrupoles?

Plan of my presentation

1. Short reminder*: Update of the ground motion generator of A. Seryi for ATF2 thanks to ground motion measurements in the ATF2 beam line

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2. Study of the stabilisation usefulness for ATF2 final focus quadrupoles (including final doublets and upstream quadrupoles)

- For the current optics*
- For the ultra-low beta optics: ***new study!***

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3. Comparison between simulated and measured relative motion of final doublets to the Shintake Monitor

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4. Conclusion on the achievement of vibration tolerances with the current configuration (rigid fixation to the floor)

**Presented at the 8th ATF2 Project Meeting (June 09)*

1. Short reminder: Update of the ground motion generator of A. Seryi for ATF2 thanks to ground motion measurements in the ATF2 beam line

Introduction

- ✓ Ground motion generator of A. Seryi: Simulation which can reproduce spatial and temporal properties of ground motion

- ✓ Input parameters of the generator can be updated to fit measurements done on various sites in the world

- ✓ Last update done by Y. Renier to fit the generator with measurements done by R. Sugahara in ATF Ring

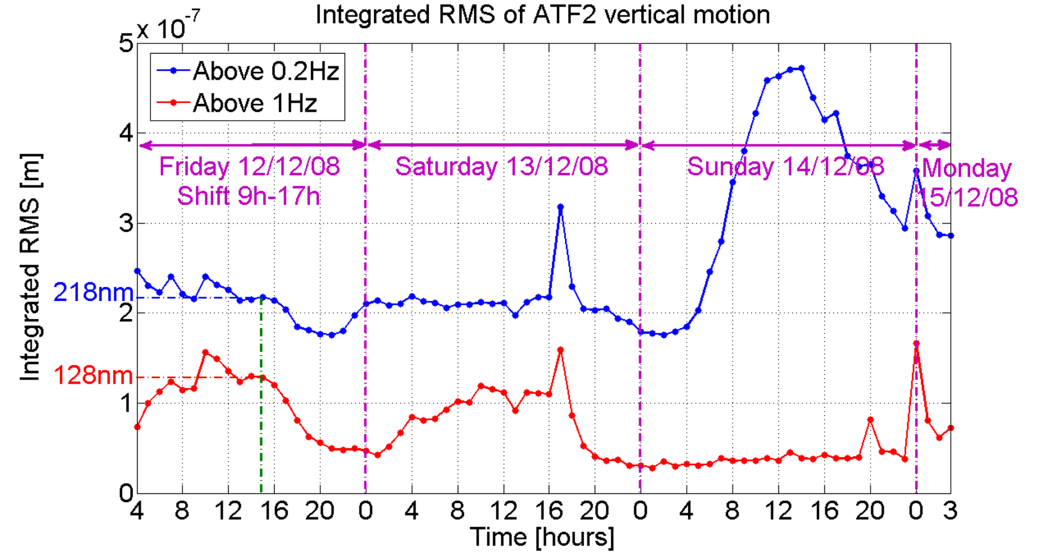
- ✓ Now, continuation of Y. Renier work to have ATF2 ground motion simulations from new measurements done by me in the ATF2 beam line
  - ➢ absolute ground motion during 72 hours
  - ➢ coherence/relative ground motion for different distances

Y. Renier and all., Tuning of a 2D ground motion generator for ATF2 simulations

Improvment of the fitting method

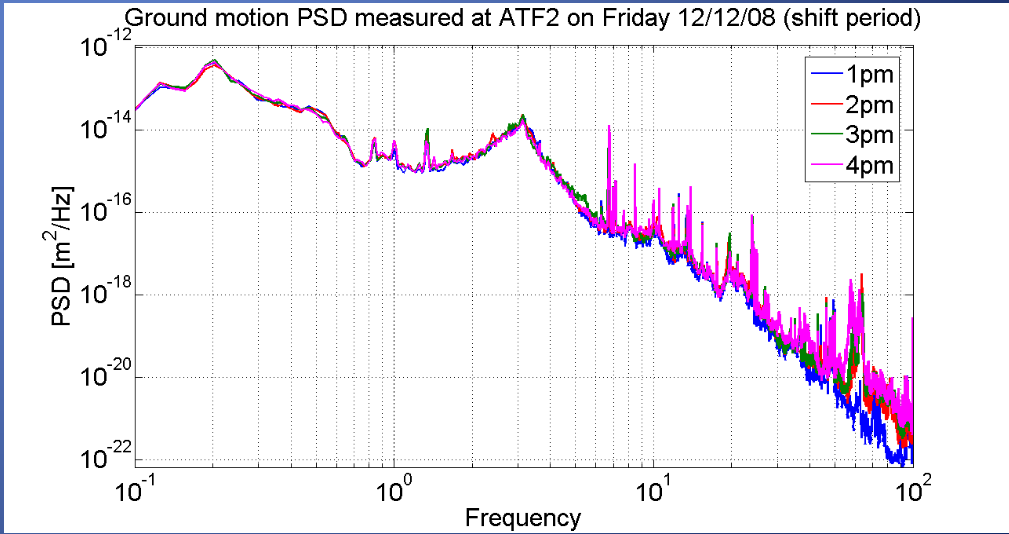
Choice of a representative absolute ground motion

Allow updating amplitude, frequency, width parameters of the generator



- ✓ **Choice of a high ground motion during shift period**
- ✓ **Friday 12/12/08 at 3pm**
  - → Above 0.2Hz: 218nm
  - → Above 1Hz: 128nm

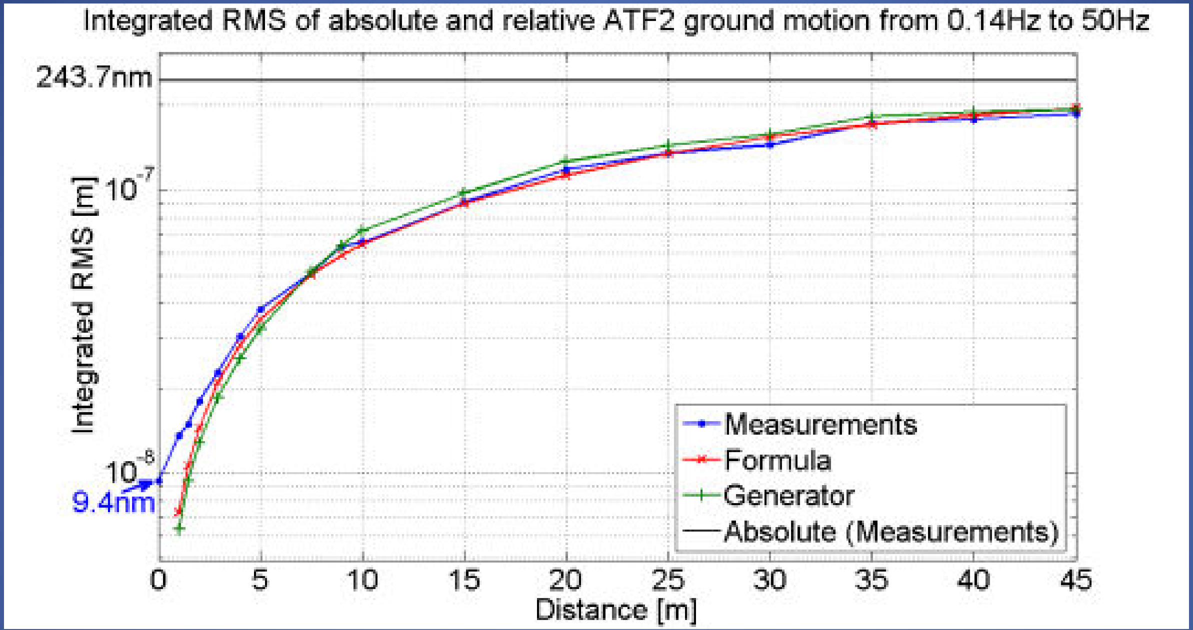
- ✓ Amplitude almost the same during 4 hours of shift
  - ➢ Choice of ground motion at 3pm representative



N.B: coherence measurements done for several dist. to fit velocity parameters

Resume of the results obtained

Integrated RMS of absolute/relative motion vs distance



- ✓ Increase of relative motion with increase of distance up to 190nm at 45m (absolute motion of about 240nm)
- ✓ Very good agreement simulations /measurements for each distance
  - ➢ Confirmed the quality of the parameter tuning
- ✓ Below 4m, measured and theoretical RM overestimated due to very high SNR needed and lower correlations than in reality (measurements)

2. Study of the stabilisation usefulness for ATF2 final focus quadrupoles

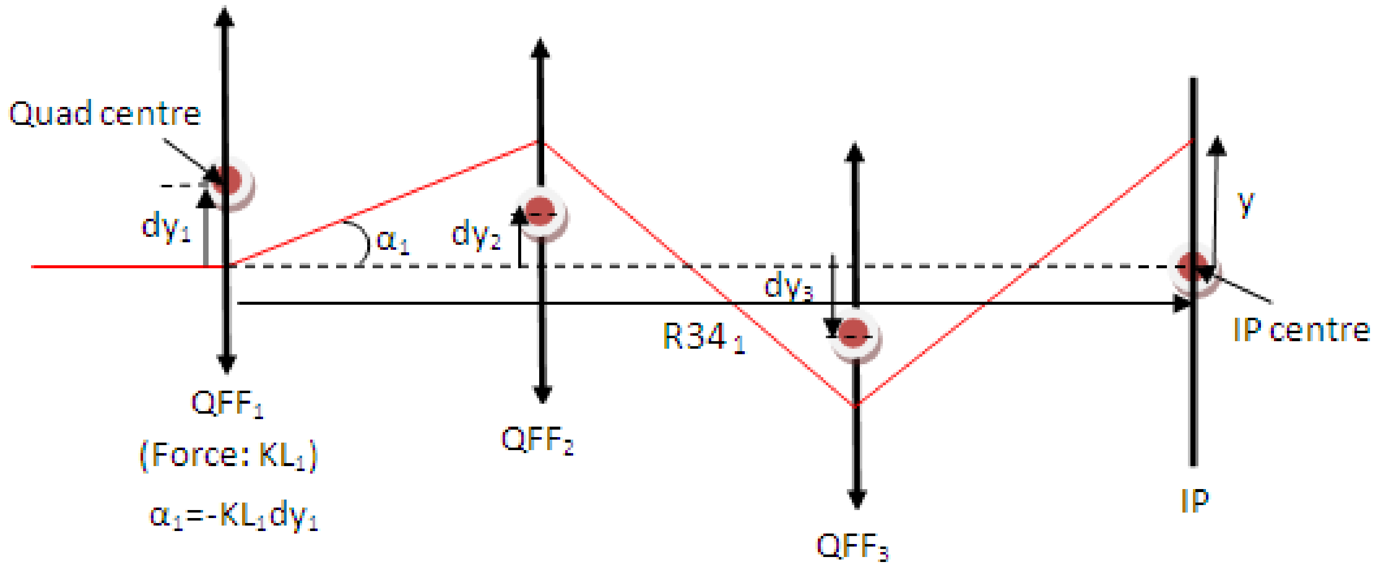
Principle of calculation

1. Use of the ATF2 ground motion generator to have relative motion $dy_i(t)$ of each FF quadrupole QFF_i to the IP (GM coherence incorporated)

2. Beam relative motion to IP due to QFF_i motion: $y_i(t)=-KL_iR34_i\ dy_i(t)$

3. Beam relative motion to IP due to motion of all quads: $y(t)=sum(y_i(t)\ )$

4. Calculation of the integrated RMS of relative motion $Y_i(f)$ and $Y(f)$ to get relative motion from 0.1Hz to 50Hz (sign not given with this calculus)

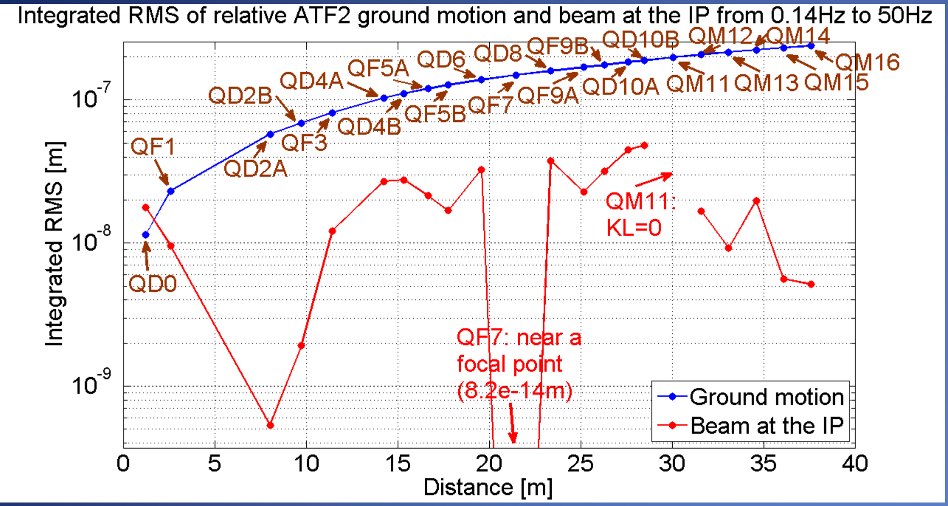


- ✓ *Sign of KL different for QD and QF*
- ✓ *Sign of R34 varies depending on phase advance*
- ✓ *Sign of dy(t) varies*

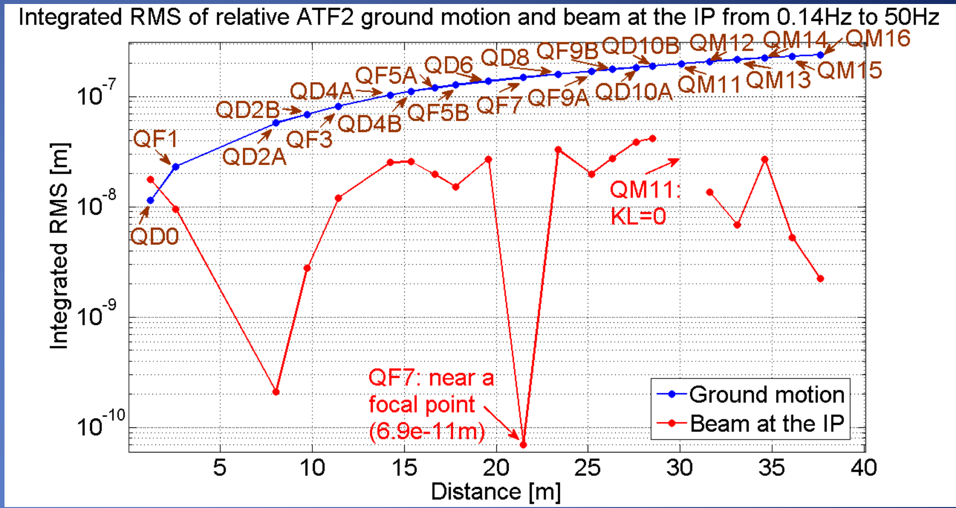
Sign of y(t) varies

Beam relative motion to IP due to jitter of each QFF_i

With the ATF2 nominal lattice



With the CLIC ultra-low β lattice



✓ Increase of relative ground motion to the IP with increase of distance

✓ Beam Relative Motion to IP from 0.1Hz to 50Hz due to motion of:

Beam RM due to:	Nominal	Ultra-low β
QD0/QF1FF (nm)	17.7/9.6	17.7/9.5
QD10A/B (nm)	44.6/48.1	38.7/41.8

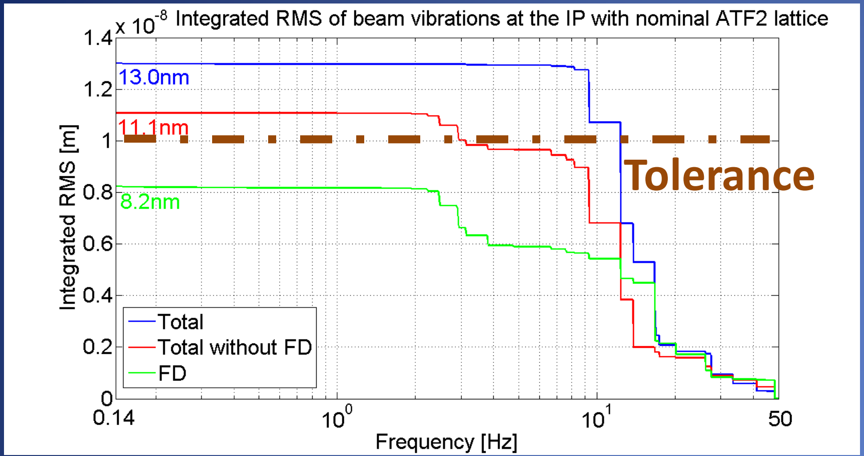
➔ **Low value:** high β but good coherence with the IP

➔ **High value:** due to high β/coherence loss

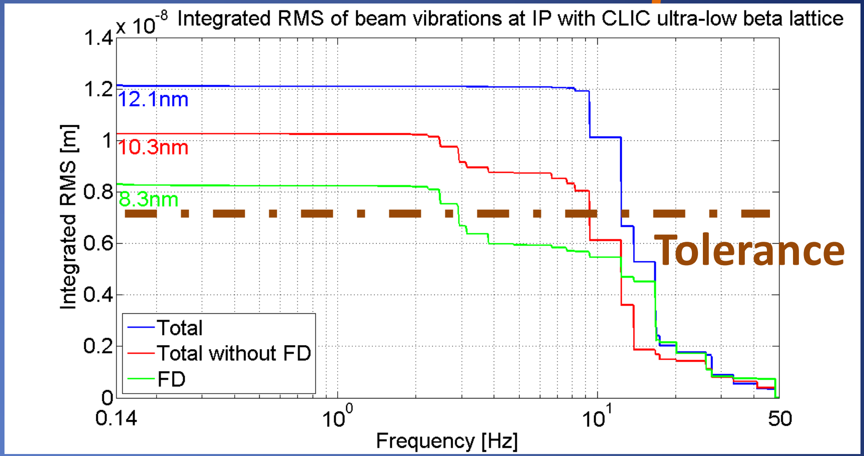
➔ **Necessity to look at beam relative motion due to jitter of all quads**

Beam relative motion to IP due to jitter of all QFF_i

With the ATF2 nominal lattice



With the CLIC ultra-low β lattice



✓ Beam relative motion to IP from 0.1Hz to 50Hz due to jitter of:

Beam RM due to (nm):	Nominal	Ultra-low β
Both QD0/QF1	8.2	8.3
All FF quads except FD	11.1	10.3
All FF quads (tolerance)	**13.0 (10)**	**12.1 (6.8)**
Tolerance achievement	**Almost OK**	**Factor 1.8 above**

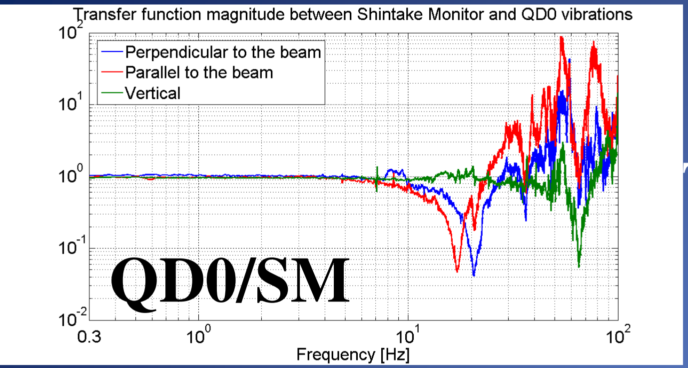
Low: D/F compensation (Both QD0/QF1)

low: lucky compensation (All FF quads except FD; All FF quads)

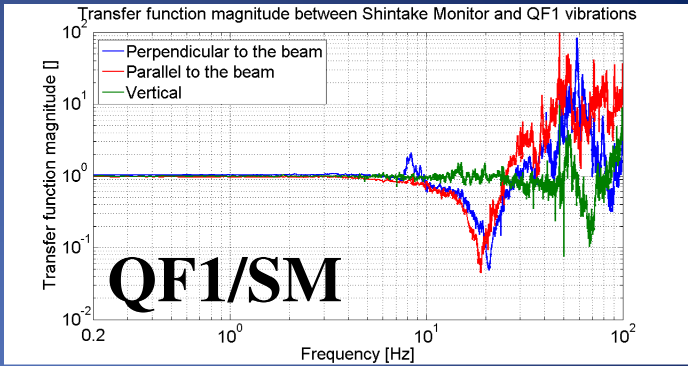
✓ It was checked changing 4 times the generator parameters (slightly and not slightly) that this lucky compensation is robust and not fortuitous

3. Comparison between simulated and measured relative motion of final doublets to the Shintake Monitor

✓ Vibration measurements of transfer function between FD and SM

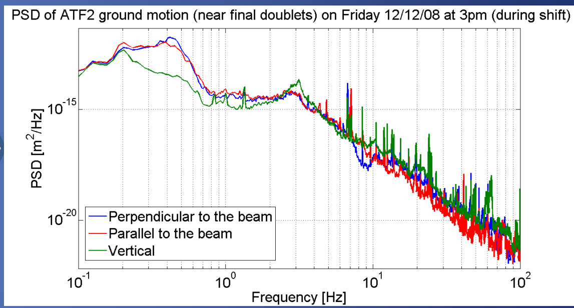


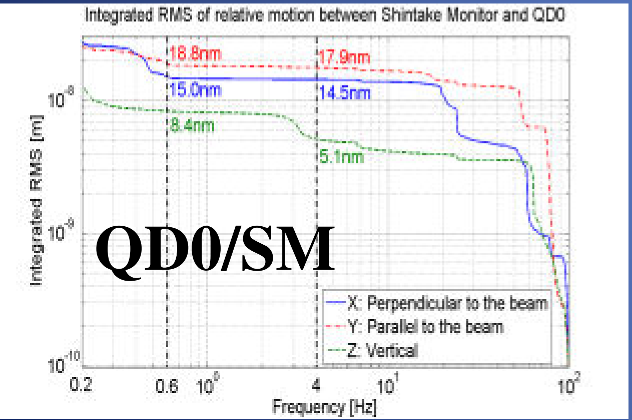
H(k)= Vibration Transfer Function (TF) between FD and SM

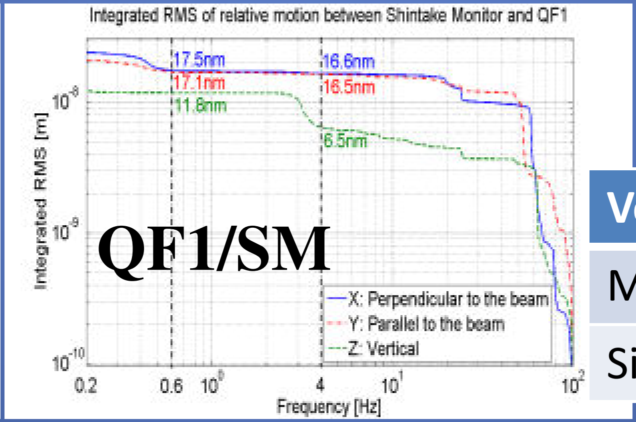


✓ Relative motion calculation by taking the representative GM

$$RMS_{int\ y-x}(k) = \sqrt{\sum_{k_1}^{k_2} [H(k)-1][H^*(k)-1] PSD_x(k) \Delta f}$$







Vertical RM	QD0/SM	QF1/SM
Measured	5.1nm	6.5nm
Simulated	11.4nm	23.1nm

- ➢ Below 4Hz: overestimation due to small error on TF measurements (around 1%) amplified by two huge peaks of GM (0.2-0.4Hz and 3.5Hz)
- ➢ Difference between measurements and simulations: due to underestimation of correlations by simulations below 4m

4. Conclusion and future prospects

✓ Jitter of some of FF quads induces separately high RM of beam to IP (up to 50nm for nominal lattice) due to high β and loss of GM coherence

✓ Due to big luck, the sum of these separate effects are well compensated and simulations give a relative motion of the beam to the IP of:

➔ 13.0nm (tolerance:10nm) for the ATF2 nominal lattice

➔ 12.1nm (tolerance: 6.8nm) for the CLIC ultra-low lattice

- Should be much lower since RM of FD to SM well lower in reality (measurements) (correlation underestimation by simulation for d<4m)

✓ Future work:

- Check in simulation this previous assumption by decreasing the distance FD/SM in order to have RM of FD to SM closer to reality

  ➔ Tolerances (especially the ones of the ultra-low beta lattice which are the most critical) may be achieved

- Even if stabilisation may not be needed, an active stabilisation will be studied in order to have a prototype for CLIC