MAD-X SIMULATIONS OF VIBRATIONS IN THE MDI REGION

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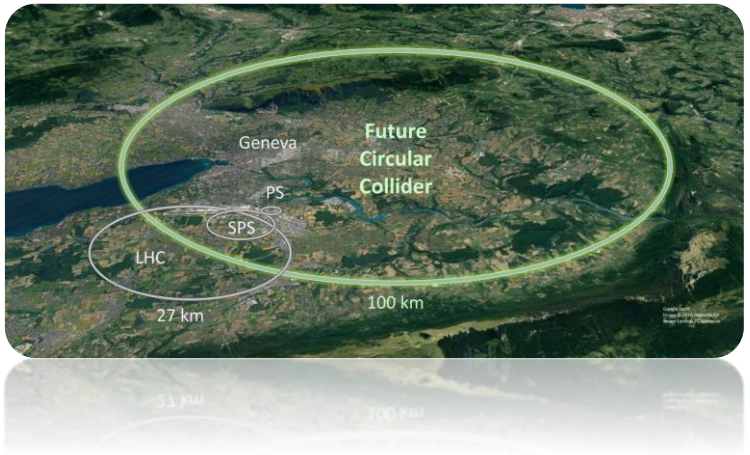
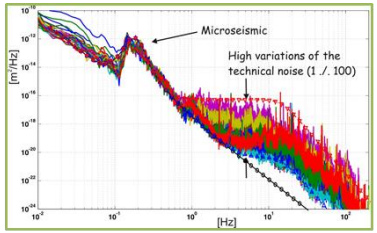
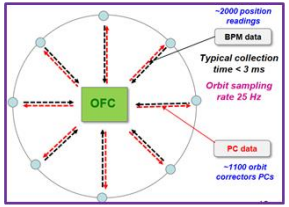
Table of contents



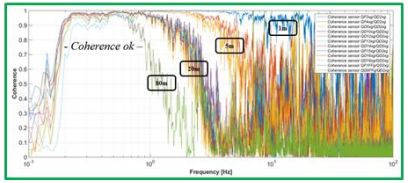
FCC-ee vibrations studies



PSD displacement of various experiment sites



LHC Feedback controller design



ATF2 coherence

Vibrations level

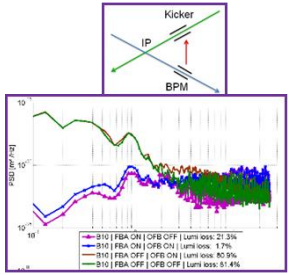
Coherence

Mechanics transfer functions

Instrumentation: resolution and noise

Beam control

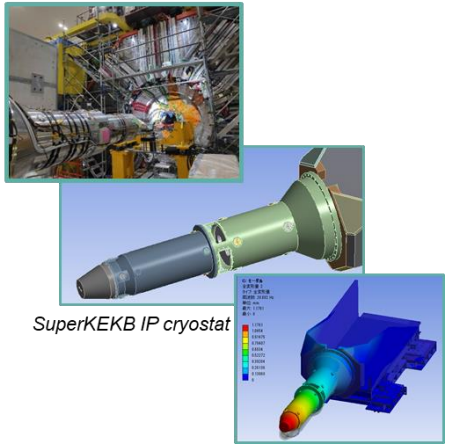
FCC-ee vibrations studies



CLIC post IP BPM feedback


LHC Beam Position Monitor


Vibration sensor


SuperKEKB IP cryostat

Context

Objectives:

- Vibrations study in the MDI region: **dynamical** misalignments study
- Complementary study to the performed misalignments study *(see Tessa Charles presentation)*
  - Difference with integration of static mechanics, with an alignment system
- Integrate dynamics beam optics with the mechanical design

Tools:

- Optics simulation with MAD-X (5.07.00)
- Z lattice considered
- Latest layout used (09/2021)*, ~91 km long

*PA31-1.0

	Z	W	H	ttbar
Energie (GeV)	45,6	80	120	175 | 182,5
σ_x(IP) (µm)	6,4	13	13,7	36,7 | 38,2
σ_y(IP) (nm)	28	41	36	66 | 68

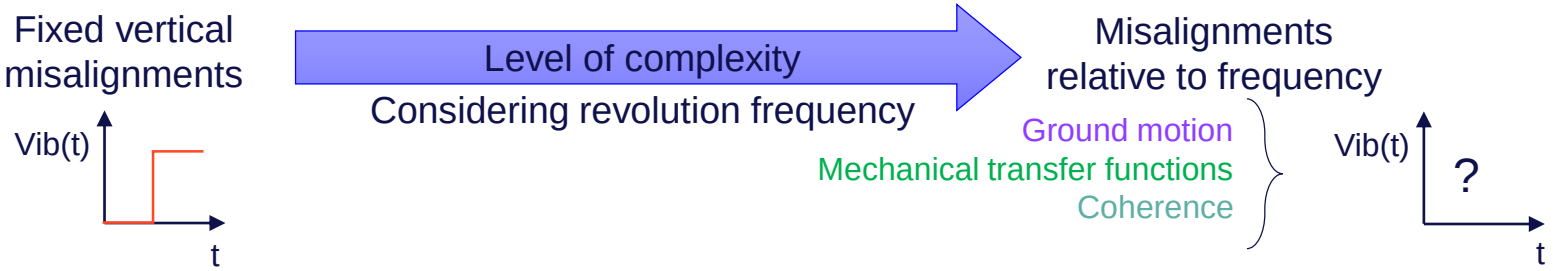
FCC-ee CDR values

Challenges

3 requirements to perform the vibrations study in the MDI region:

1. Magnets misalignments: representation of ground motion and/or cultural noise
2. Iterative simulations:
   - Reloaded lattice at each tour of the accelerator with the injection of offsets induced by the previous misalignments
3. Evaluation of the impact of vibrations on emittance and/or beam size

Concerning the magnets misalignments model:

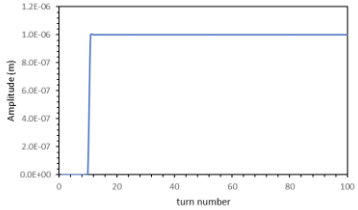


First works with MAD-X

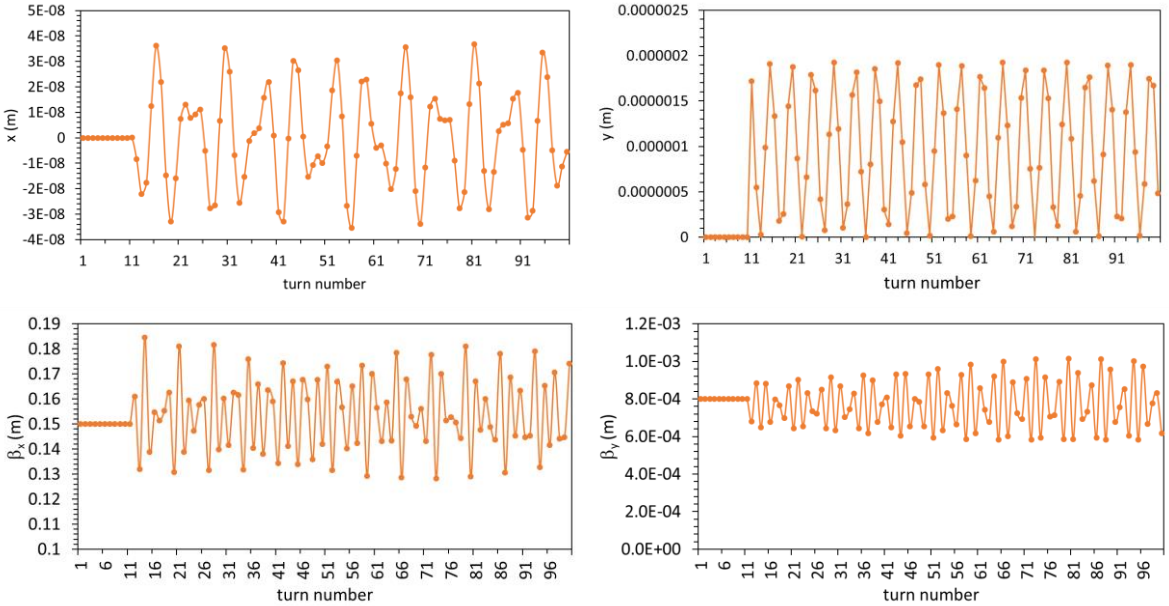
Introduce static misalignments and perform iterative simulations:

- TWISS module used
- 100 turns
- No global correction considered

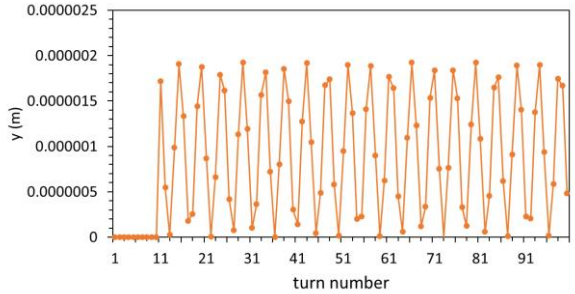
- Observables @ IP2: β_x, β_y and x, y offsets
- “Old” Z lattice, 2 IPs

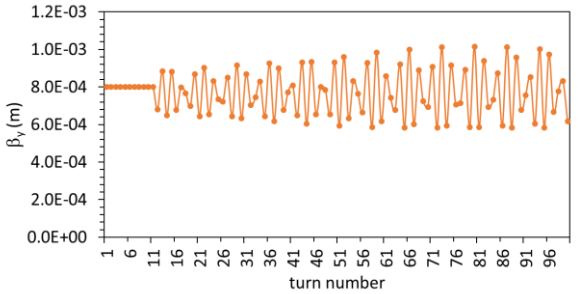


Vertical misalignment of QC1



First works with MAD-X (2)





- No divergence observed for x and y offsets
- **Orbit is closed at each turn**
- Not consistent with cumulative results

New procedure

Use MAD-X Tracking…

Aim: Simulate a bunch of particles and propagate misalignments over thousands of turns

(First) Initial conditions: RF off ⇨ VOLTCA1 = 0

1. Calculation of nominal Twiss parameters
2. Slice the sequence to prepare for thin lenses tracking: differentiate arc cells and insertions (RF + experiments)
3. Start the sequence at a dedicated marker near the first RF cavities
4. Match the global tunes to the nominal ones
5. Track particles

New procedure

Use MAD-X Tracking…

Work in progress:

- In 2. :

It seems that there is no need to slice quadrupoles, but only sextupoles, octupoles and crab-cavities.
When ready, use the standardized thin sequence (see Ghislain Roy's talk).

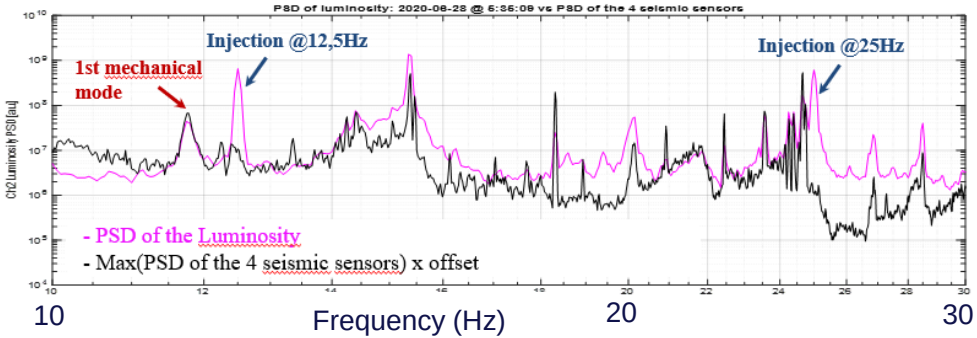
- In 5.:

Define a macro (tr$macro), which can apply misalignments relative to the number of turn (tr$turni)
Evaluate the beam size
⇨ Define misalignments depending to the number of turn, which is related to frequency

Work on SuperKEKB

Related optics simulations

Correlation of vibration and luminosity measurements (see Laurent's talk):



Ongoing work: perform optics simulations to make the comparison with measurements

- Induce vibrations of the cryostats in the simulations: PSD displacement measured
- Evaluate luminosity losses

- Work performed with SAD
- Possibility to compare results with MAD-X when SAD/MAD-X converter available (see Leon's talk)

Summary and perspectives

Conclusions:

- Ongoing work to define properly vibrations in MAD-X (PSD)
- Integration of mechanical design in optics simulations
- Complementary study to misalignments results
- Parallel made with SuperKEKB vibrations studies
- Gradually complexify vibrations simulations in MAD-X for MDI studies with the add of mechanical specifications ⇨ check criticality of vibrations in FCC-ee

Summary and perspectives

Lots of things to do before getting and presenting numerical results…

Long-term perspectives:

- Integrate mechanical transfer functions in the definitions of beam elements misalignments
- Consider RF and Radiation (6D problem)
- Test global and local corrections
- Inclusion of previous misalignments and correction
- Consideration of both e^+ and e^- beams (2 different beam pipes)
- …

Many thanks to: M. Boscolo, T. Charles, M. Hofer, G. Roy, L. Van Riesen-Haupt, F. Zimmermann

Thank you
for your attention!