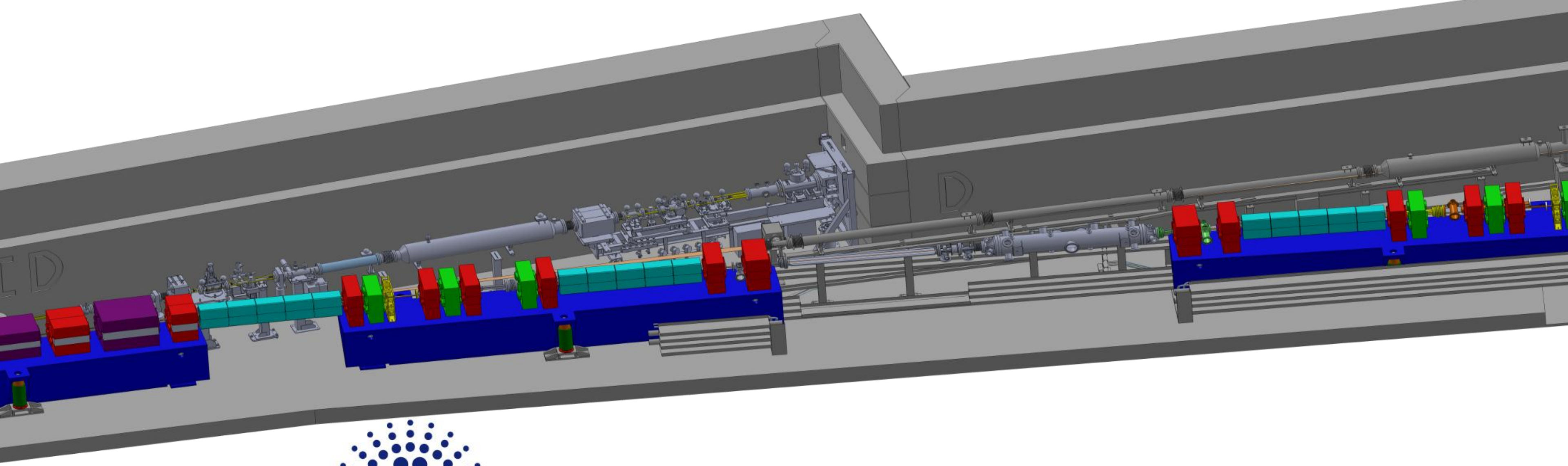


ESRF | The European Synchrotron

Fast orbit feedback for the ESRF-EBS

ALERT 2016, Trieste, 14th-16th September 2016

E. Plouviez, B. Roche, F. Uberto

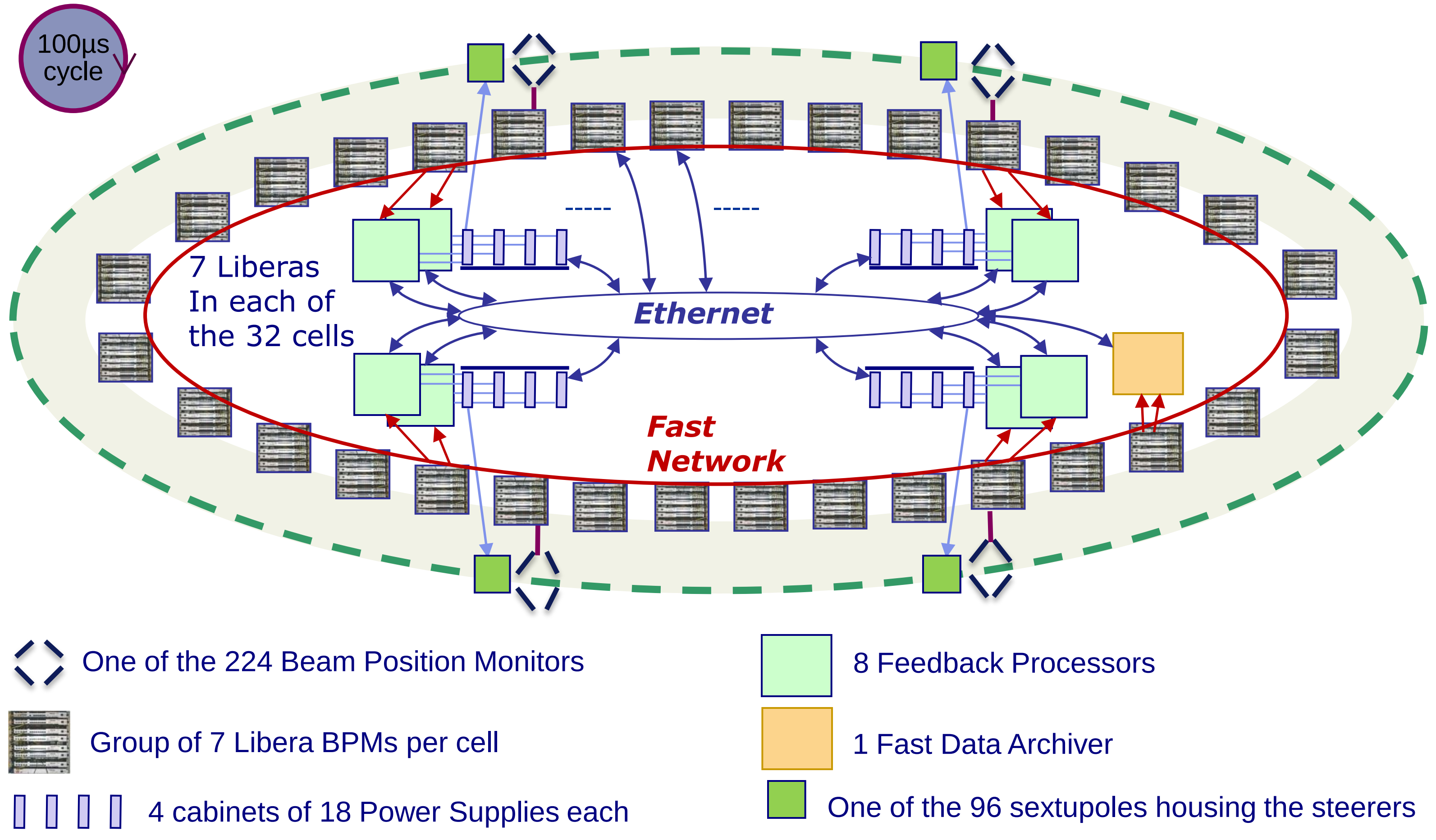
OUTLINE

I. Current vs. future fast orbit feedback

II. Performances

III. Test of the hybrid slow/fast loop with the current ring

Architecture



Key caracteristics:

- PI loop, with 100 μs period (using DSL Communication Controller (CC))
- 50 Hz notch in the feedback loop (main orbit perturbation)
- Feedback on RF frequency @ 10 Hz

→ Beam stability is below 1 μm RMS in the straight sections (middle term stability, not taking into account ID changes, thermal effects, tide effect, …)

→ For the ESRF-EBS, beam stability requirements are comparable (roughly same vertical beam size)

For the ESRF-EBS we will reuse the current fast orbit feedback

→ reduces the development time

→ reduces costs

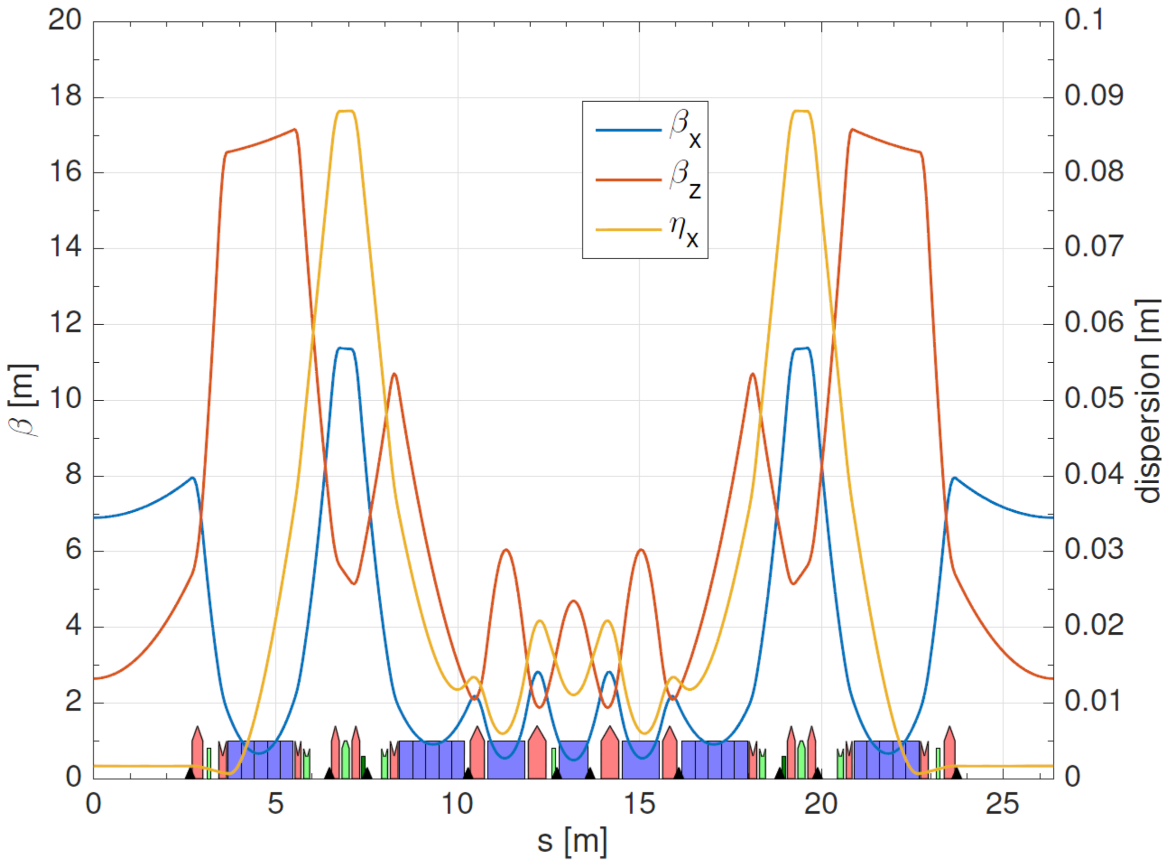
→ reduces risks

but…

Issues:

- The orbit control for the ESRF-EBS will require 320 BPMs and 288 correctors to put the beam optimal orbit in term of coupling, lifetime, etc.
- The Libera Brillance is not available any longer
- The design of the wide bandwidth power supplies of the present ring is not compatible with standard/sextupole based correctors of the ESRF-EBS

BPMS AND CORRECTORS IN THE EBS LATTICE



Black triangle: BPM

Small green rectangle: fast corrector

Large green rectangle: slow corrector (sextupole)

ESRF VS. ESRF-EBS FAST ORBIT FEEDBACK

	ESRF	ESRF-EBS
BPM (total)	224	320
Libera Brillance (wt CC)	224	192
Libera Spark (no CC)	0	128
Correctors (total)	96	288
Fast correctors	96	96
Slow correctors	0	192

We will use :

- **192 Libera Brilliance and 128 new and simpler BPM electronics (Libera Spark)**
- **96 fast correctors magnets and 192 slow/sextupole based correctors using new power supplies**

ESRF-EBS ORBIT CONTROL SCHEME

The two subset of BPM/correctors will be controlled by two different feedback loop:

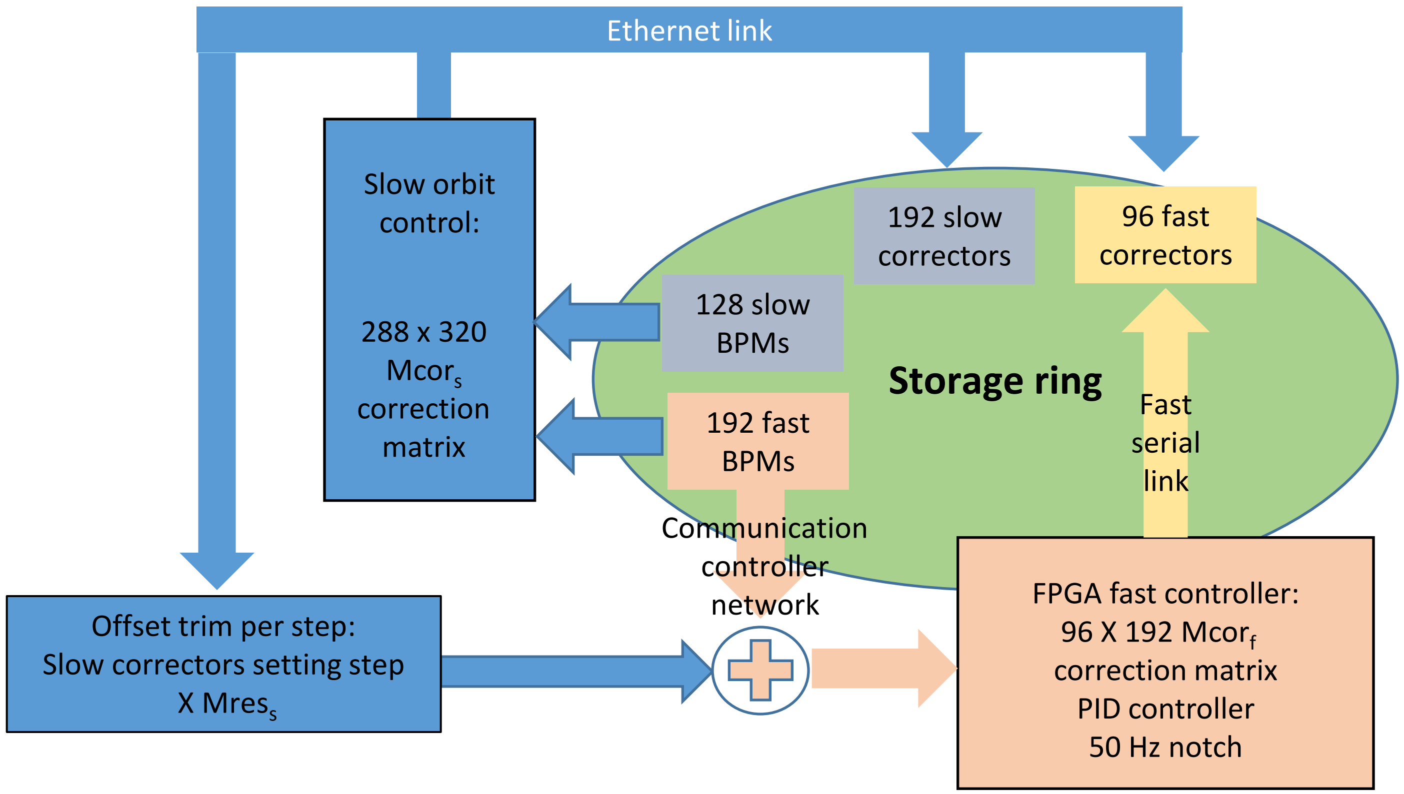
- **Fast loop: 192 BPMs and 96 correctors using the present fast orbit control system (DLS CC and FPGA power supplies controllers)**
- **Slow loop: all 320 BPMs (Libera Brillinace + Spark) and all 288 correctors (96 fast correctors (slow inputs) and 192 slow correctors)**

The slow and fast loops have to exchange data in order to converge toward the same closed orbit and avoid corrections aiming at opposite orbit change.

→ Communication between the two loops by adding an offset to the position data of the 10 kHz outputs of the BPMs

→ Offset resolution: 16 nm

ESRF-EBS ORBIT CONTROL SCHEME



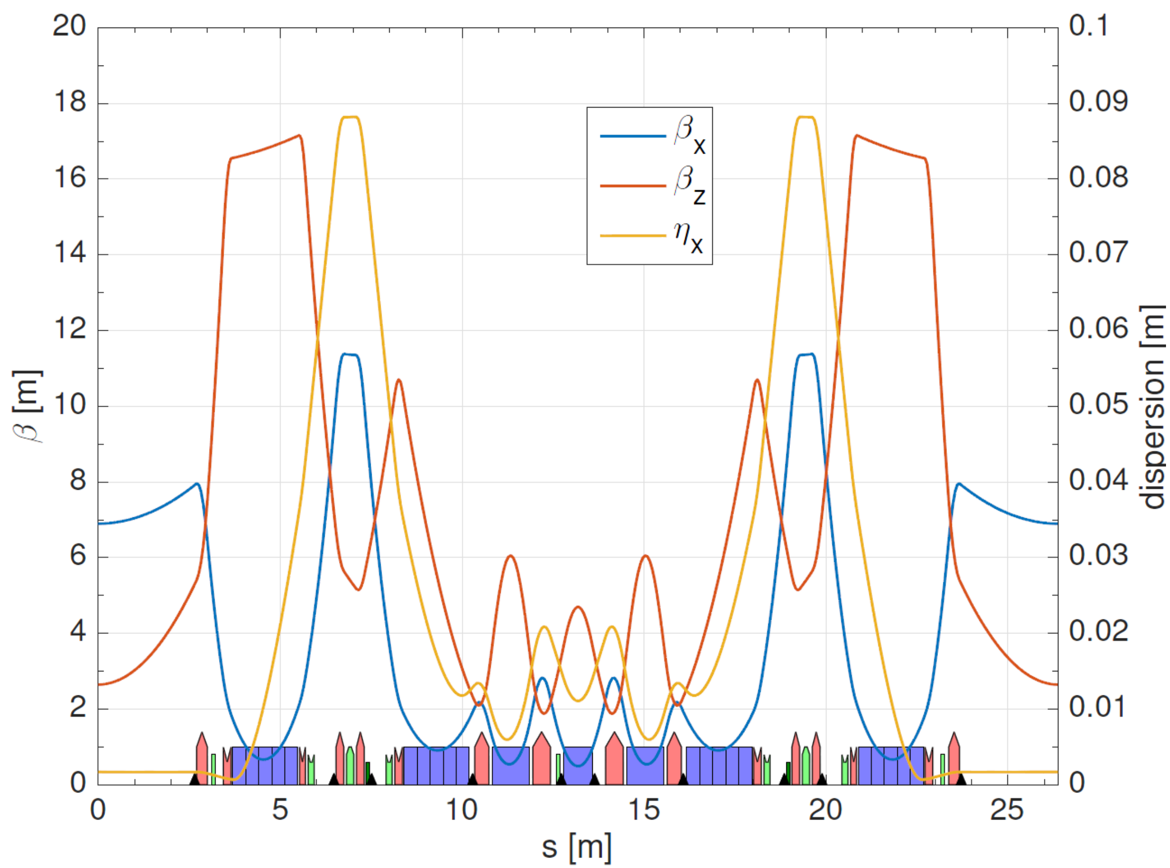
Hybrid slow/fast orbit control flow chart

OFFSET TRIMMING PRINCIPLE

1. Initially: set the FOC X, Z position offset at the value of the X,Z position reading of the slow system (=> no DC fast correction)
2. After ΔT, measure the orbit [X_i Z_i] using the 320 BPMs
3. Calculate the correction to apply using the full correction matrix
4. Calculate what will be the new orbit [X_{i+1} Z_{i+1}] after the application of this correction
5. Apply the correction using the full correctors set (the FOC will try to fight this correction)
6. Change the FOC offset according to [X_{i+1} Z_{i+1}]: now the FOC does not fight the slow correction anymore…
7. Leave the FOC fight the additional fast orbit distortion with the reduced set of fast BPMs and correctors and a reduced correction matrix

BPMs:

- 1,2,5,6,9,10



Correctors:

- 1, 5 and 9 ie adjacent to the straight section + one in the middle of the cell

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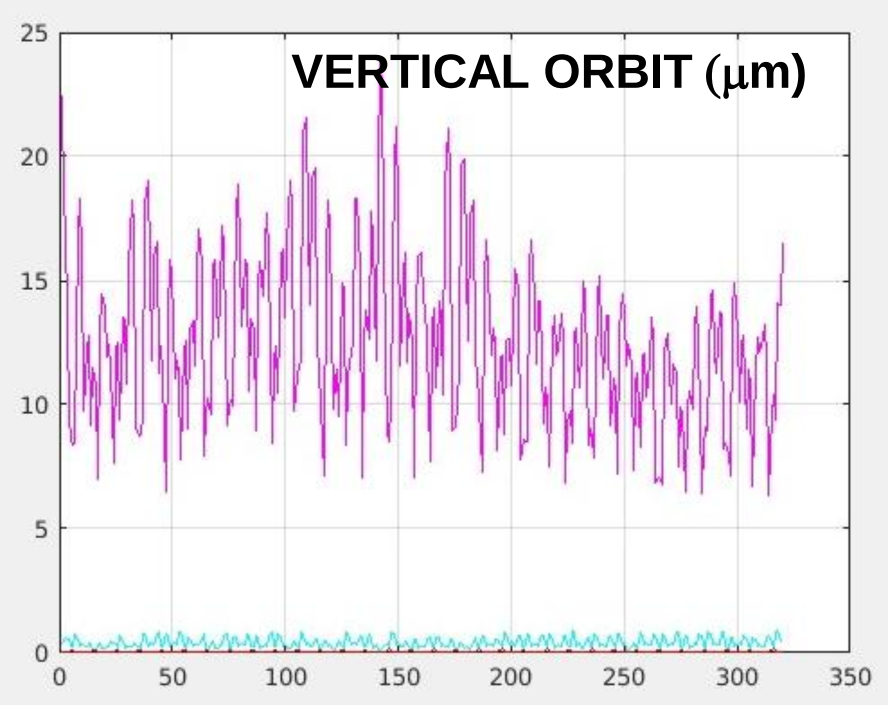
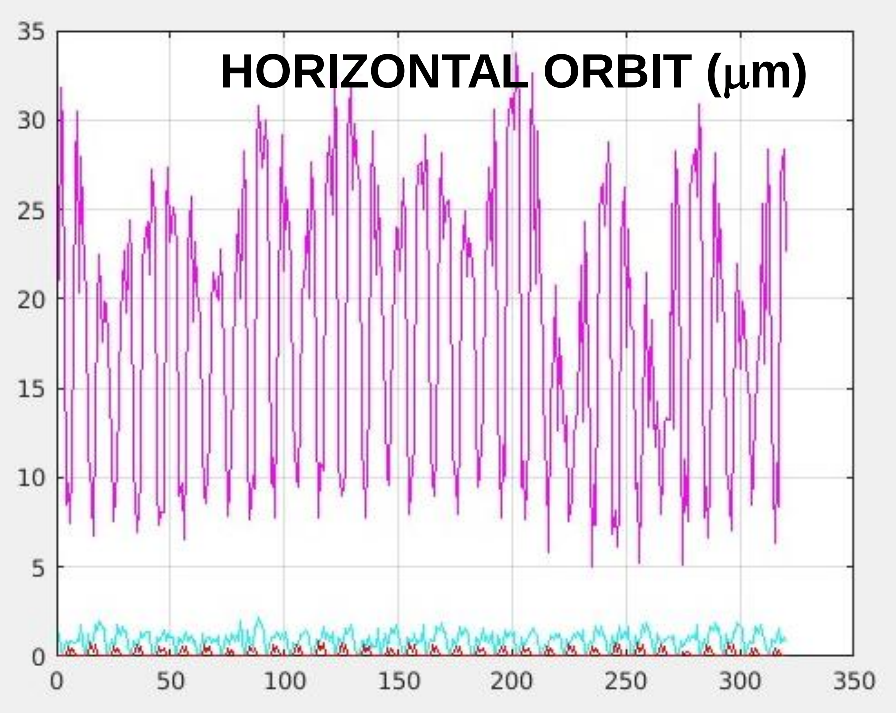
SIMULATION OF QUADRUPOLE ERRORS

Random quadrupoles displacement:
orbit corrected using the full set or the reduced (192 BPMs and 96 correctors) set of BPMs and correctors

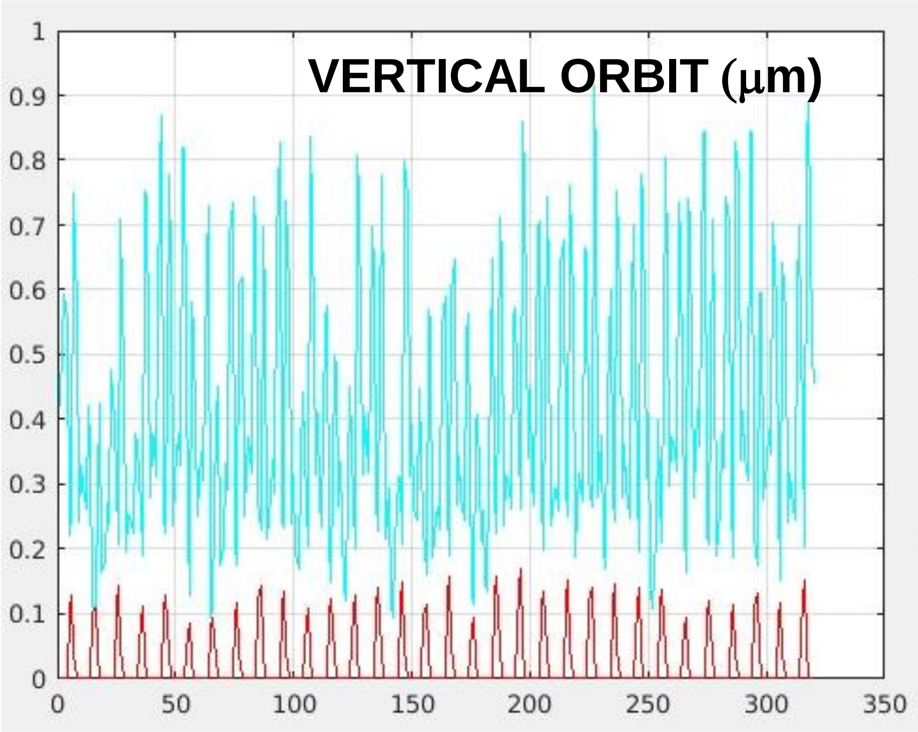


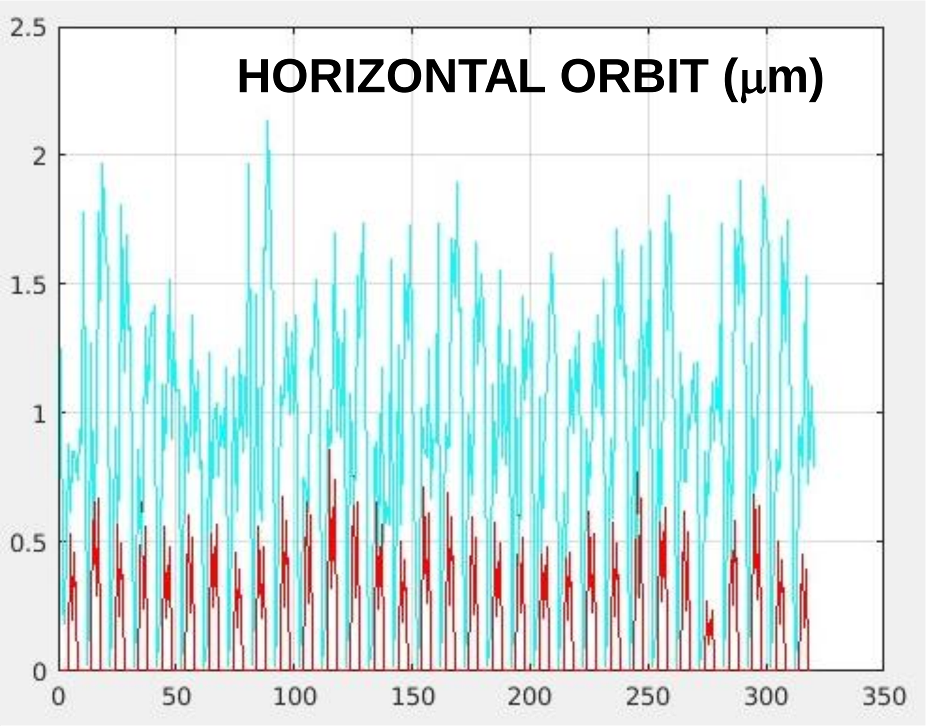


distorted orbit (purple), corrected orbit (blue and red)

SIMULATION OF QUADRUPOLE ERRORS

Details of the corrected orbits:



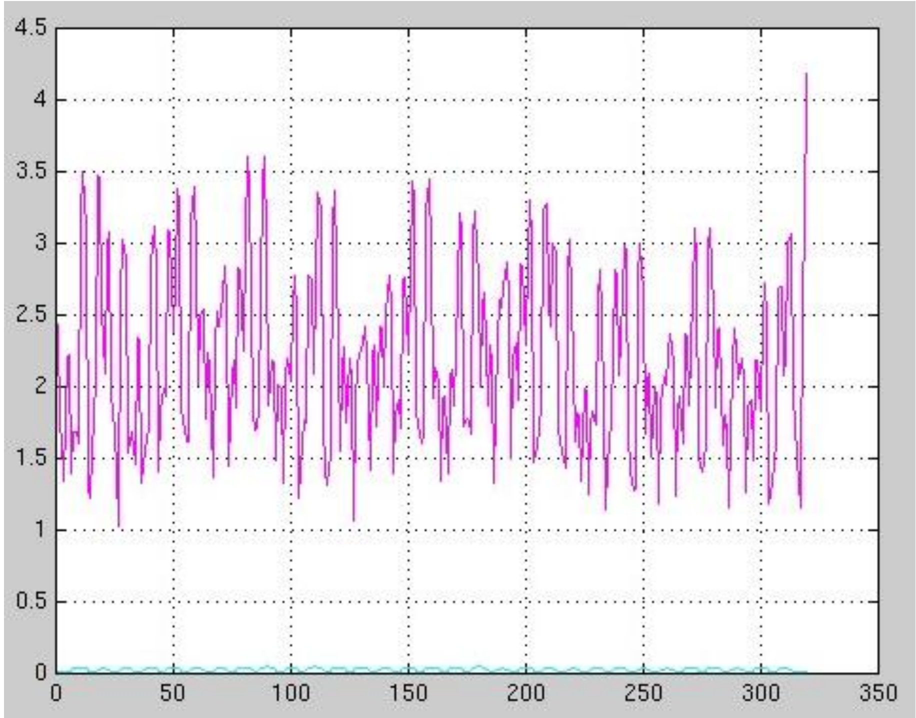


320 BPMs and 288 correctors (red)
192 BPMs and 96 correctors (blue)

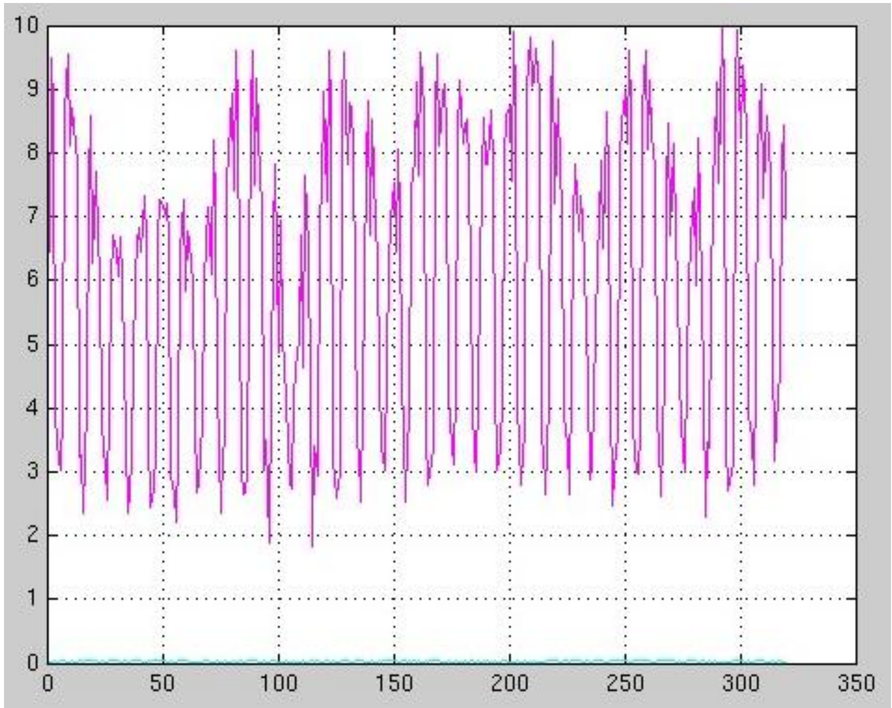
SIMULATION OF RANDOM KICKS FROM INSIDE THE STRAIGHT SECTIONS

Kicks in straight sections are well corrected with the reduce set of BPMs & correctors

VERTICAL ORBIT (µm)



HORIZONTAL ORBIT (µm)



distorted orbit (purple), corrected orbit using reduced set of BPMs & correctors (blue)

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Test of the hybrid loop in order to asses:

- long term stability of the loop
- quality of the correction at high frequency (above 1 Hz)
- quality of the correction at low frequency

TEST OF THE HYBRID FEEDBACK LOOP WITH CURRENT RING

To test the hybrid loop:

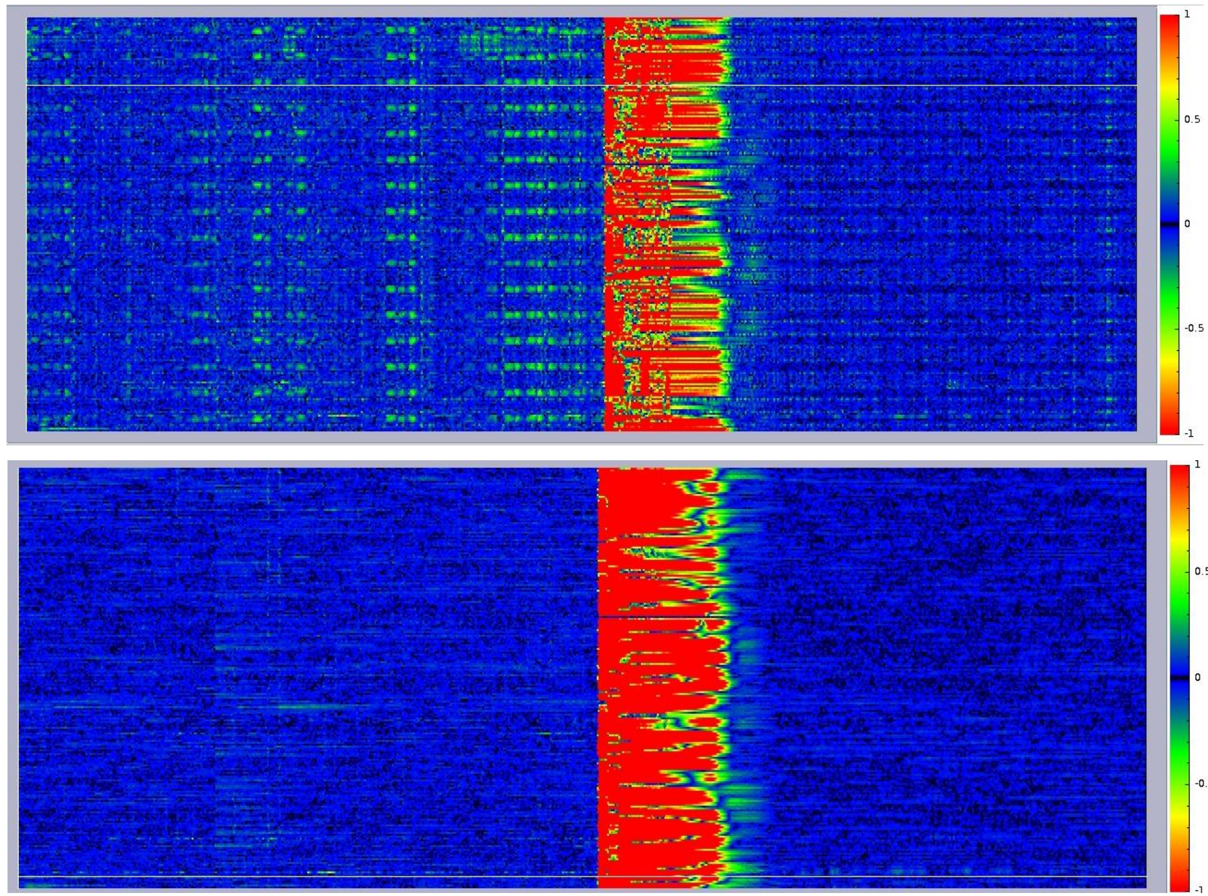
64 BPM are removed from the fast orbit feedback, only their slow output is read

32 correctors are removed from the fast orbit feedback, only controlled by the slow loop

TEST OF THE HYBRID FEEDBACK LOOP WITH CURRENT RING

- Horizontal scale: 12 minutes full span
- Upper plot: horizontal plane
- Lower plot: vertical plane
- Vertical axis: BPM 1 to 224
- Color scale: +/-1 μm full scale, red =1 μm

Hybrid feedback loop **Regular loop**



CONCLUSION

For the ESRF-EBS we will adapt the current fast orbit feedback in order to match its requirements

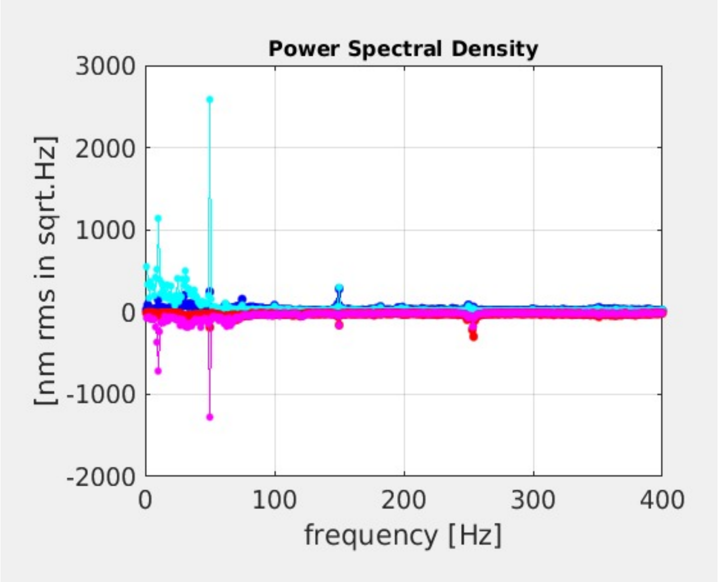
→ Best solution in terms of cost, development time and risks

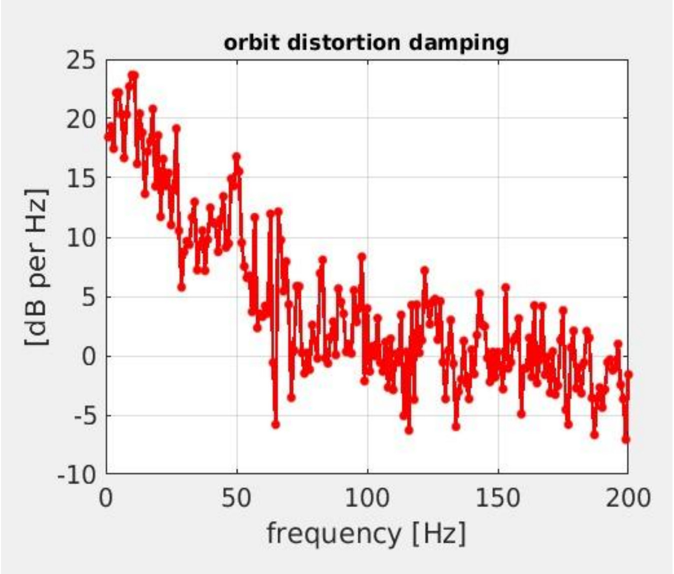
Simulations and test with the present ring shows that the foreseen scheme for the futur orbit control of the ESRF-EBS meets the requirements

Many thanks for your attention

EXTRA SLIDES

LIMITED NUMBER OF BPMS AND CORRECTORS VS. LIMITED BANDWIDTH





Spectrum of the orbit distortion:
Light blue: horizontal without feedback,
Dark blue: horizontal with feedback,
Purple: vertical without feedback,
Red: vertical with feedback

Fast correction effect versus frequency in dB

THE REDUCTION OF THE DAMPING OF THE ORBIT DISTORTION DUE TO THE REDUCTION OF THE BPM AND CORRECTORS NUMBER IS NEGLIGIBLE ABOVE A FEW HERTZ