# Exploiting Digital BPMs at ELETTRA

IWBS02
Spring-8, Japan
December 4 - 6, 2002

## A fast local orbit feedback and the feedforward system for the compensation of an Electromagnetic Elliptical Wiggler (EEW) dynamic orbit distortions

**D. Bulfone**

# Outlook

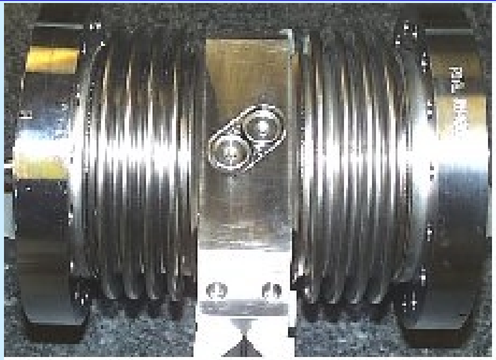
- *Low-Gap BPMs with Digital Detector*
- *Local Orbit Feedback Test*
- *Feedforward Correction System for the compensation of the EEW dynamic orbit distortions*

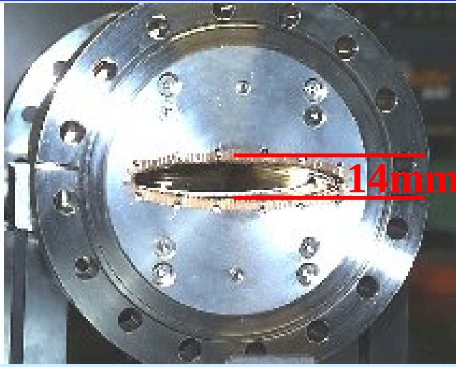
# Low-Gap BPMs with Digital Detector

• Two new-type BPMs located either side of an Insertion Device:

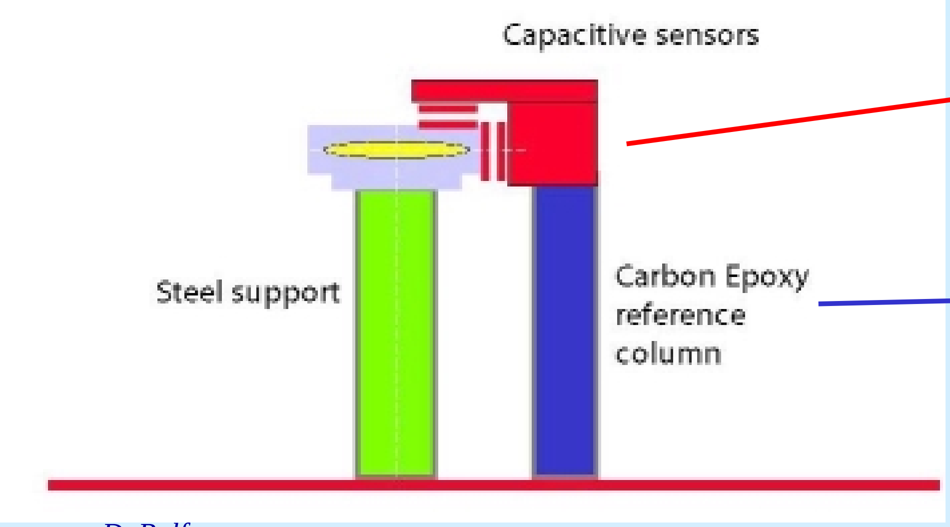
> New mechanical design of the sensor (14 mm gap)

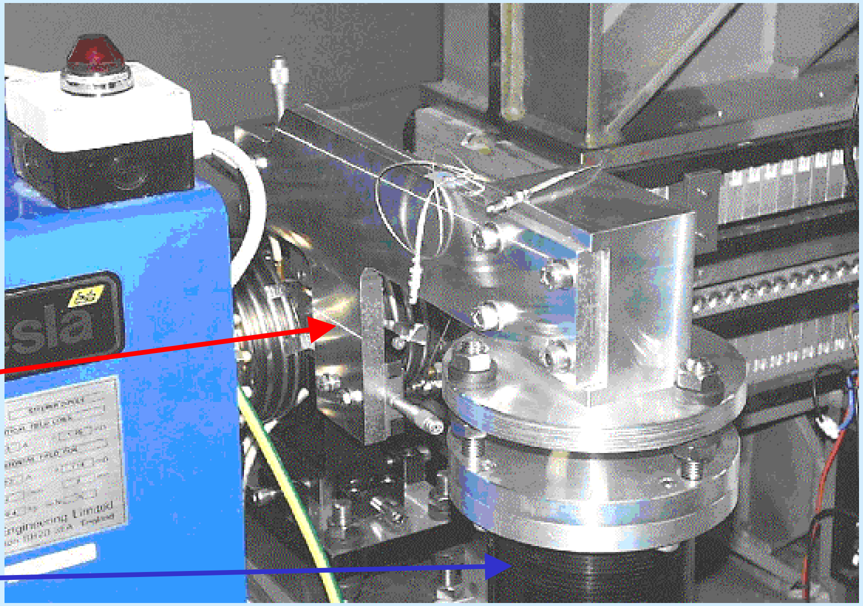
> Residual mechanical drifts monitored by contact-free capacitive sensors with respect to a Carbon fibre reference column



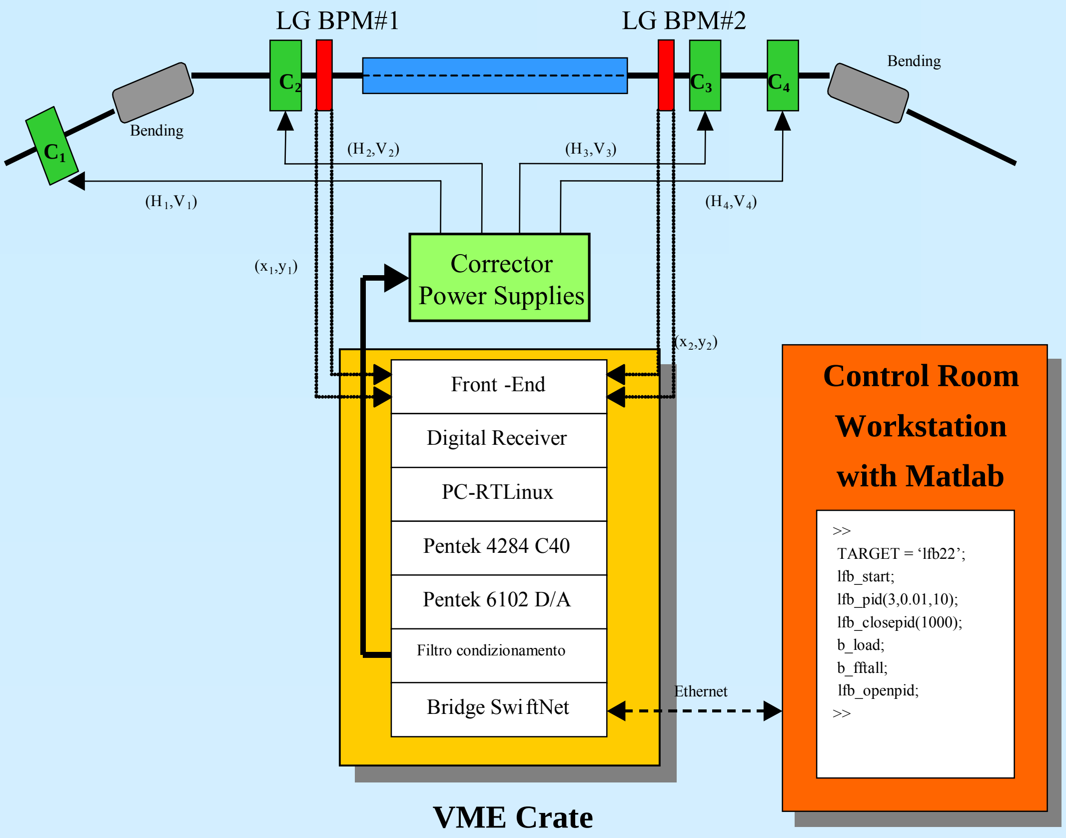



• RF Front-end and digital detector electronics (collaboration with SLS and Instrumentation Technologies)



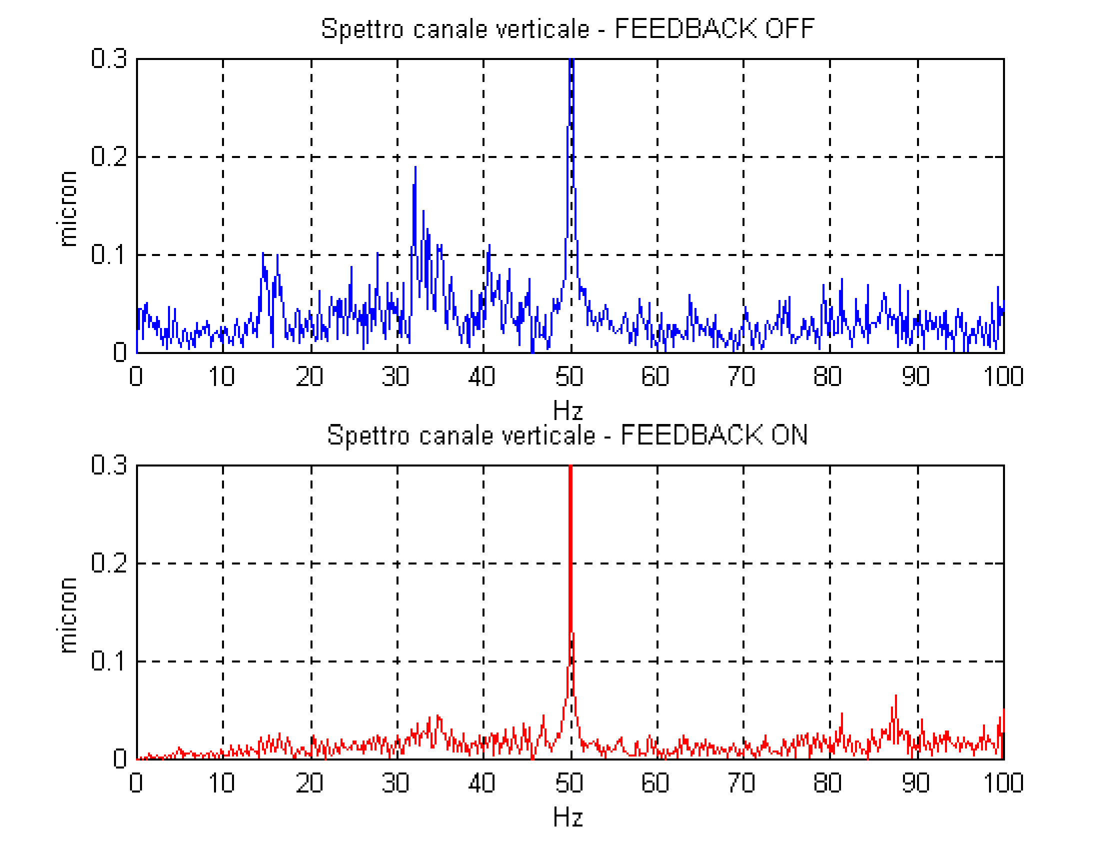
# Local Orbit Feedback Test

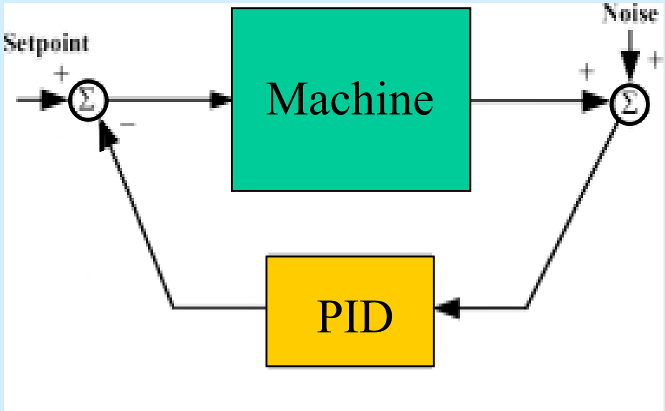



- Four corrector magnets local bump that corrects the electron beam position and angle at the ID centre
- Closed loop in both horizontal and vertical planes
- Beam position sampling rate = 8kHz

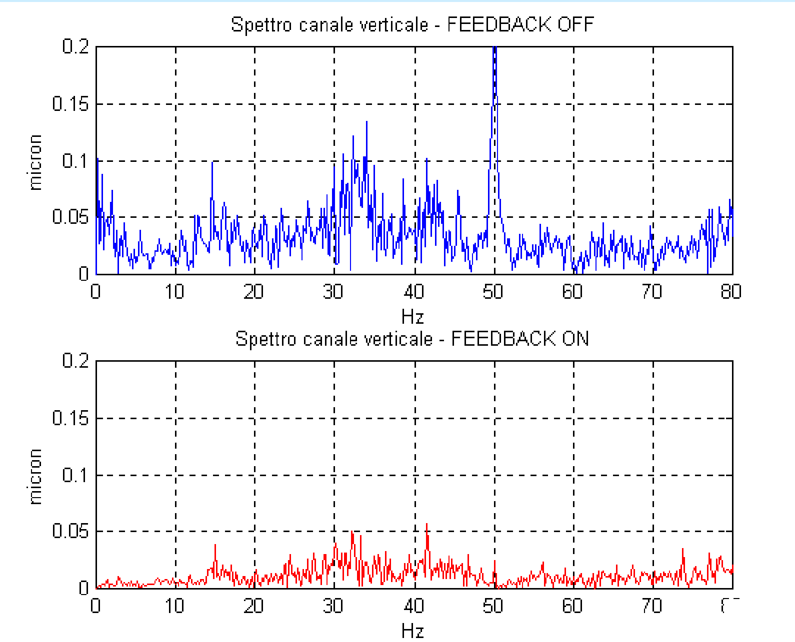
# Local Orbit Feedback Test

• PID (Proportional Integral Derivative) controller adopted to reduce low frequency components of the beam noise spectra

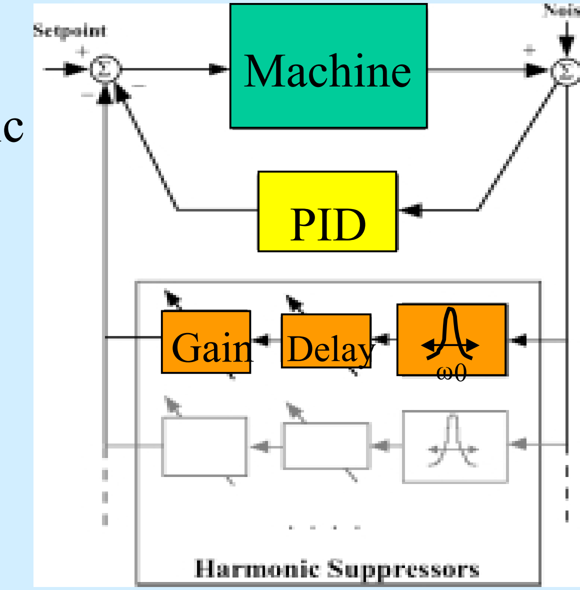


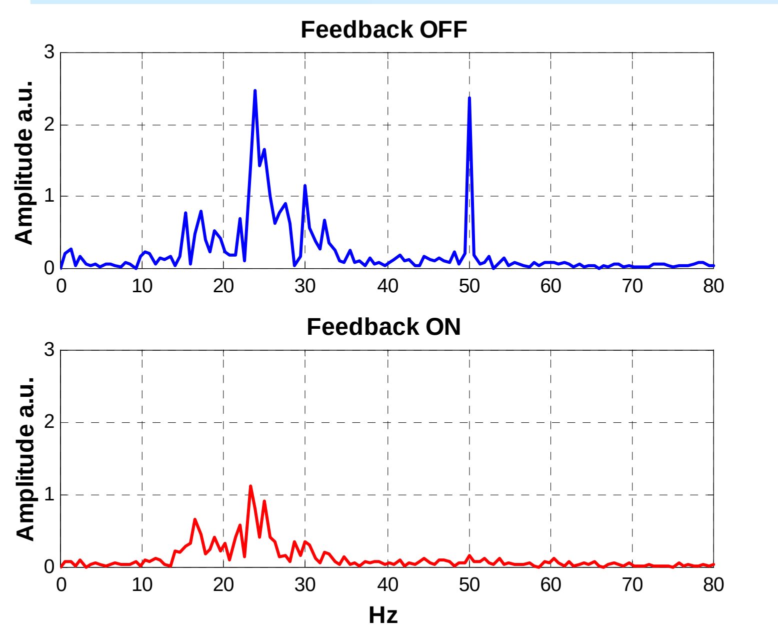
# Local Orbit Feedback Test




- PID regulator plus narrow-band harmonic suppressor at 50 Hz (and harmonics).



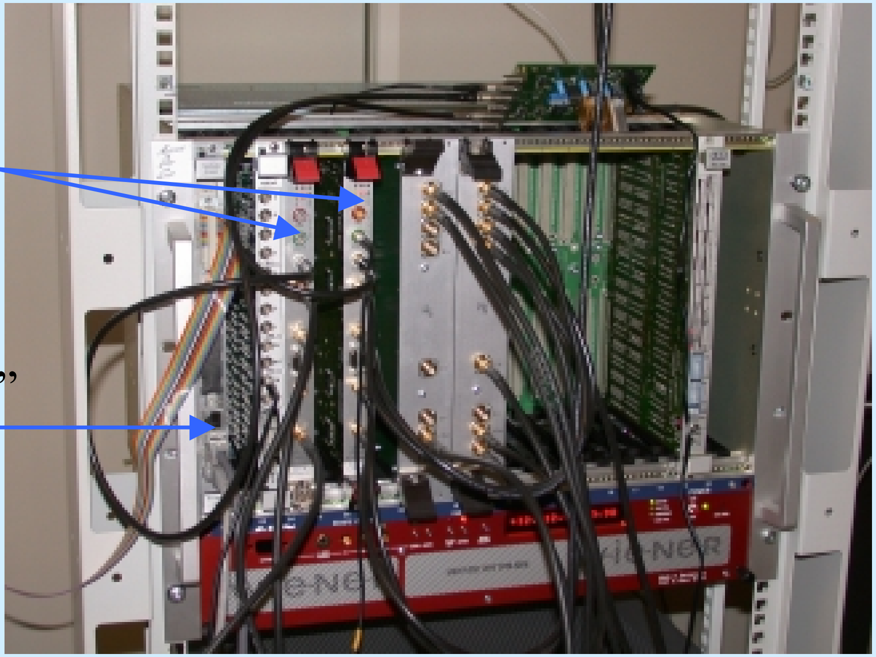

- Beam position spectra at low-gap BPM #1 with local feedback off/on. The rms of the position signal in the 0-80 Hz range is reduced from 1.24 µm to 0.2 µm.




- Beam position spectra at photon-BPM along the corresponding beam-line

# Local Orbit Feedback Test

## - Comments & Plans



• Low-gap BPMs with digital electronics are suitable for fast orbit feedbacks.

-> Optimize Digital Down Converter (DDC) latency time vs. internal filters configuration (from 350 to 200 µs, 8kHz output rate)

• Feedback digital processing executed by "standard" control system G4 PowerPC/Altivec based board with real-time Linux operating system (RTAI)

-> no dedicated DSPs

• Guidelines:

> continue installation of low-gap BPMs with digital detector electronics on other ID straights for local orbit feedbacks

> develop global orbit feedback based on:

- low-gap BPMs plus a subset of existing rhomboidal ('old-type') BPMs
- both equipped with the new digital detector and RF front-end electronics

• Smooth installation, keeping existing BPM 'strategic' functionalities (position interlock at IDs)

• Scalable system architecture, allowing for integration of additional BPMs/correctors as long as they become available.

# Feedforward Correction System for the compensation of the EEW dynamic orbit distortions



**- *Preamble***:

• Electromagnetic Elliptical Wiggler (EEW) in operation since 1997

• Helicity varied by changing horizontal magnetic field:

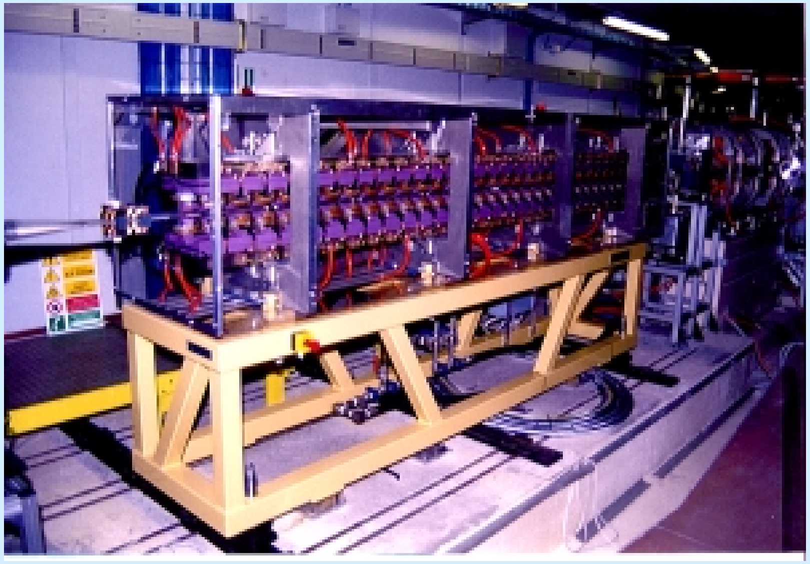
> DC mode: slow ramps

> AC mode (trapezoidal/sinusoidal), frequencies up to 100Hz (sinusoidal)

• Residual closed orbit distortion compensated by feedforward system based on two pairs of horizontal/vertical coils installed at each wiggler end

• DC mode: correction coils lookup table values obtained by off-line calibration based on minimization of closed-orbit distortion

**- *Objective***: Determine the lookup table values when the EEW is operated in AC mode, taking into account dynamic effects and non-linearities (increasing with operating frequency).

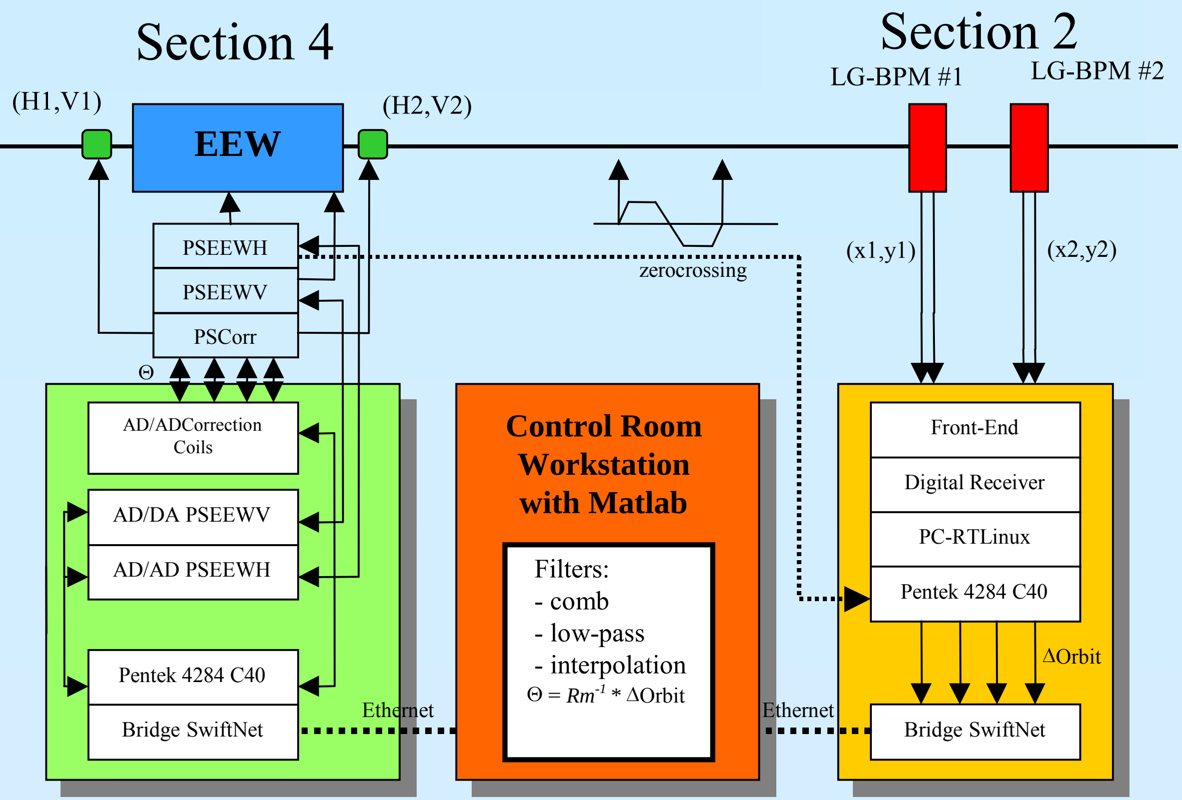


# Feedforward Correction System for the compensation of the EEW dynamic orbit distortions

## - Procedure

**1.** Measure response matrix Rm between correction coils and low-gap BPMs

**2.** Synchronously measure periodic orbit distortion using the low-gap BPMs while running EEW with the desired periodic waveform




**3.** Filter out beam noise that is not generated by the EEW:

- average many periods

- low-pass, notch filters at 50Hz

**4.** Interpolate to obtain four arrays of fixed length and subtract DC

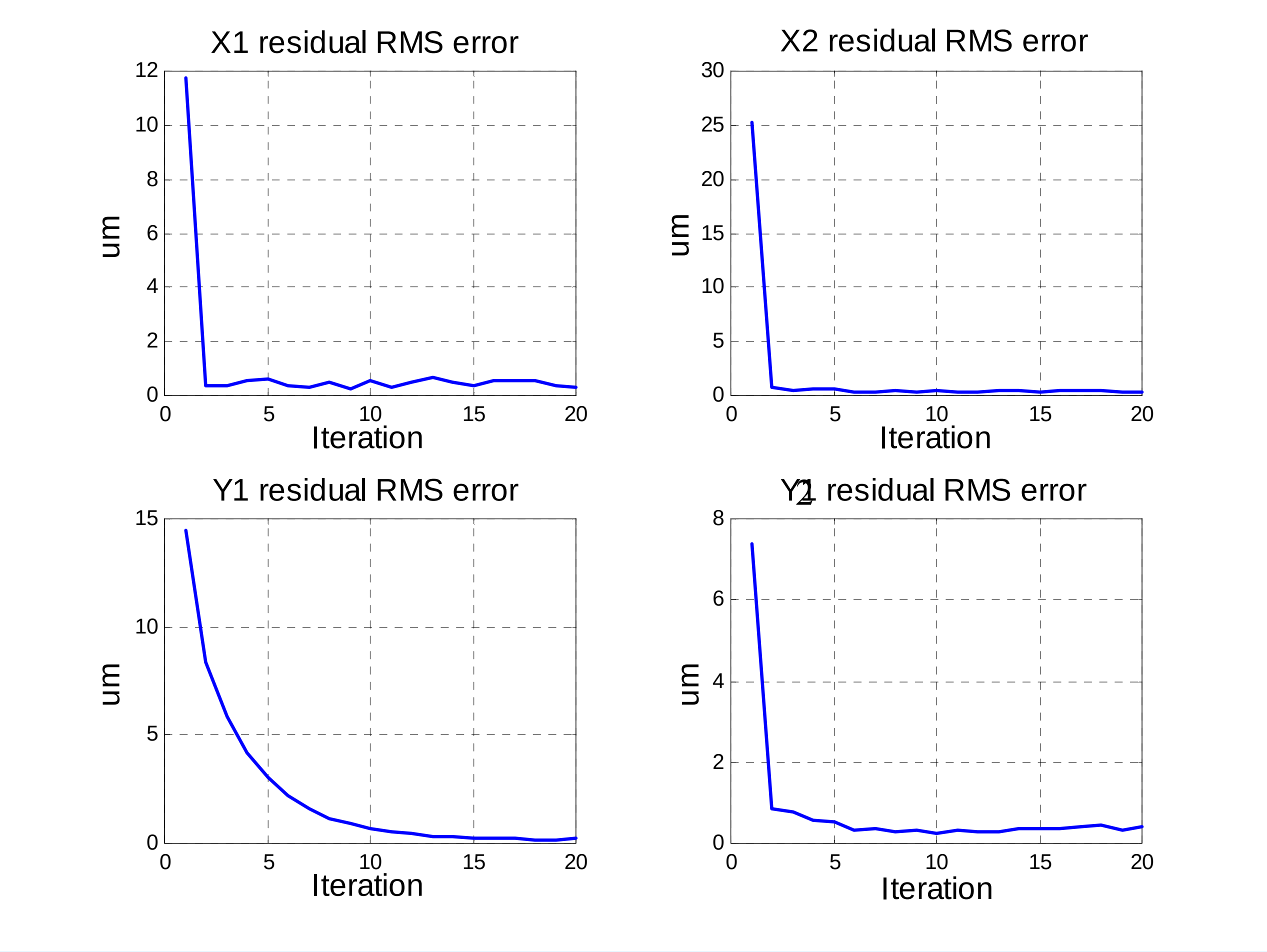
**5.** Calculate correction coils lookup tables by multiplying $-Rm^{-1}$ by the "cleaned" orbit distortion vectors.

**6.** Iterate from 2.

# ***Feedforward Correction System for the compensation of the EEW dynamic orbit distortions***



- Iterative converging process
- Example: Sine wave at 11Hz $I_h = \pm 260A$

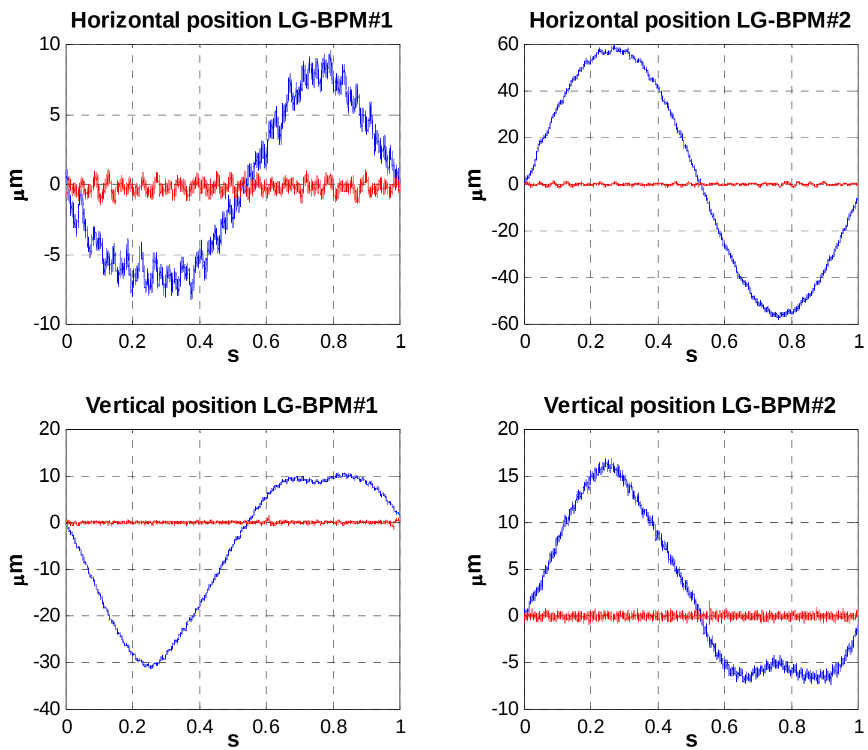


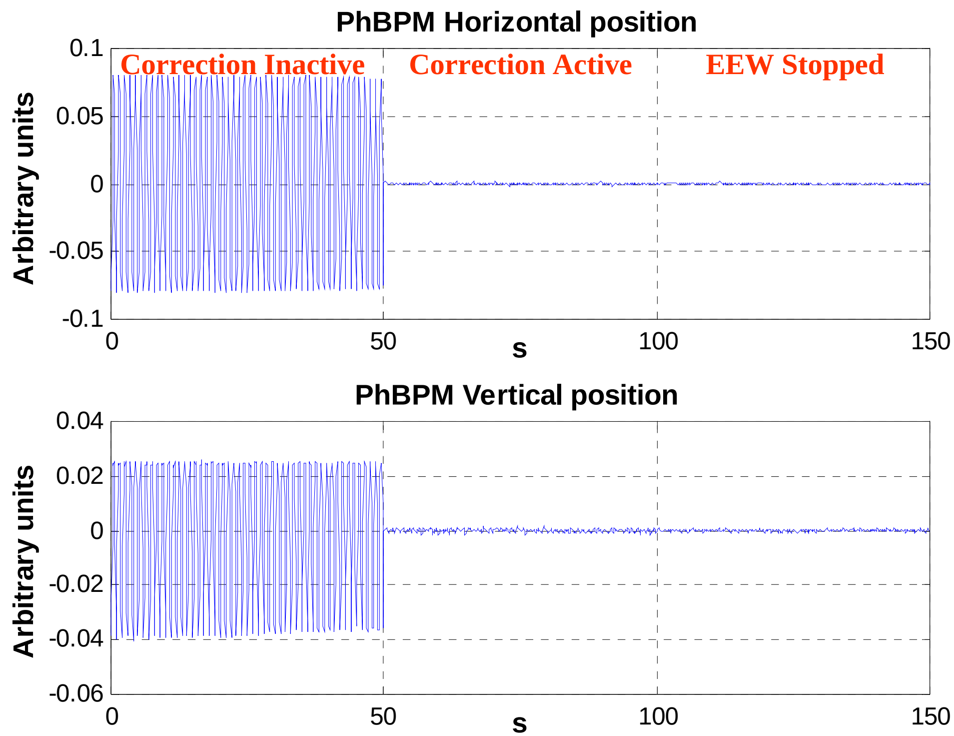

- RMS of the residual orbit distortion at the low-gap BPMs during the optimization iterations

# *Feedforward Correction System for the compensation of the EEW dynamic orbit distortions*



- Sine wave at 1Hz




- Orbit distortion at low-gap BPMs: blue without feedforward, red with feedforward correction

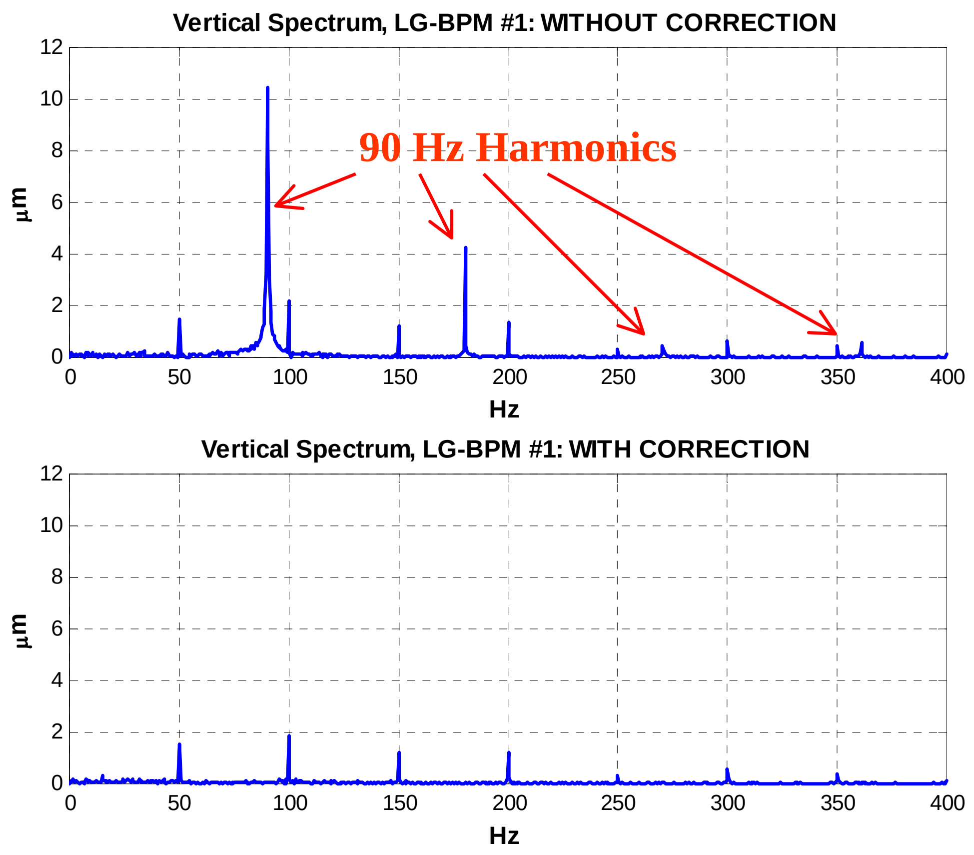
- Photon BPM readings with feedforward correction inactive, active and EEW stopped

# *Feedforward Correction System for the compensation of the EEW dynamic orbit distortions*



• Sine wave at 90 Hz

- Vertical position spectra from low-gap BPM#1, showing that the harmonics of the EEW switching frequency are eliminated by the feedforward correction system




***- Status***:

• "AC mode" lookup tables routinely used during Users shifts (one set of tables per modulation waveform)

***Thanks to***: *R. De Monte, M. Ferianis, V. Forchi', G. Gaio, M. Lonza, G. Mian, L. Pivetta, L. Zambon.*