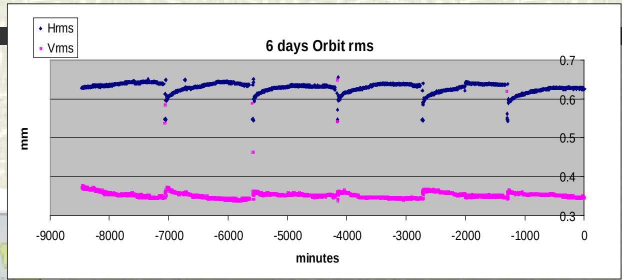
Orbit Stabilization at ELETTRA

An important ingredient of Beam Quality



www.elettra.trieste.it

E. Karantzoulis   Workshop on Beam
Orbit Stabilization, SPRING-8, Japan

Why Orbit control ?

- *The users need beams that are spatially repeatable and stable otherwise they lose intensity or get steps in their spectra -* But how stable should it be? How much and for how long?

Ideally their source point should not move at all but everything drifts and their optics too (top-up needed)

and since from design the third generation light sources due to their low emittance, the amplification factor for closed orbit distortions against quadrupole misalignments is large while the presence of strong sextupoles generate a high sensitivity to the optical distortions

Orbit MUST a priori be controlled

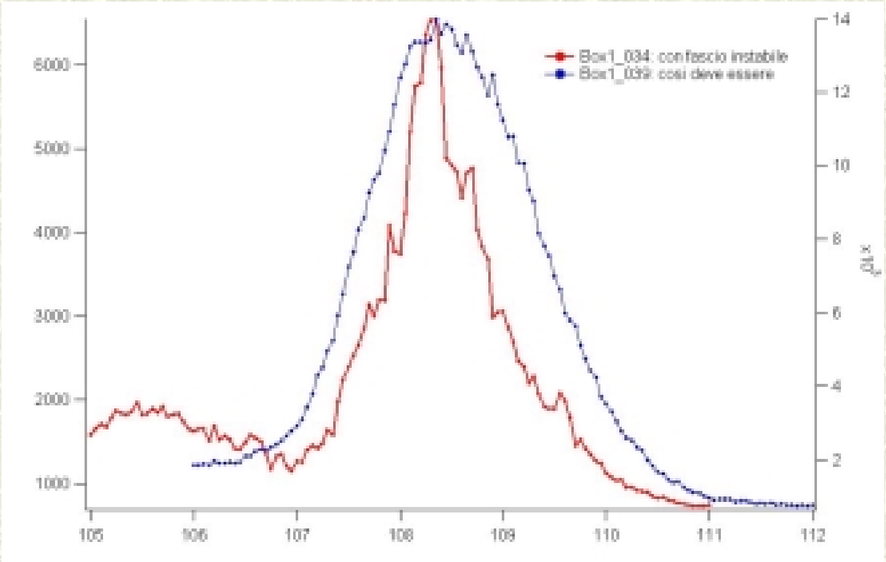
What users tolerate

It depends upon their type and time of measurements. In general flux changes of 1% or position changes of ± 3 μ are well tolerated. This however means that at the source point the angle should be kept stable at a < 1 μrad level. This is in general possible provided that the detectors can give this accuracy and the correctors do not ripple.

Experiments with fast acquisition time experiments tend to ignore drifts and small orbit changes but are sensitive to noise if the acquisition time is comparable i.e. some tens of msec

What users tolerate 2

On the opposite side are the experiments with long acquisition time do not tolerate fast drifts and abrupt changes in the orbit however tend to tolerate very fast changes like up to 100 Hz. In this case a slowly drifting orbit is better than a noisy corrected one.



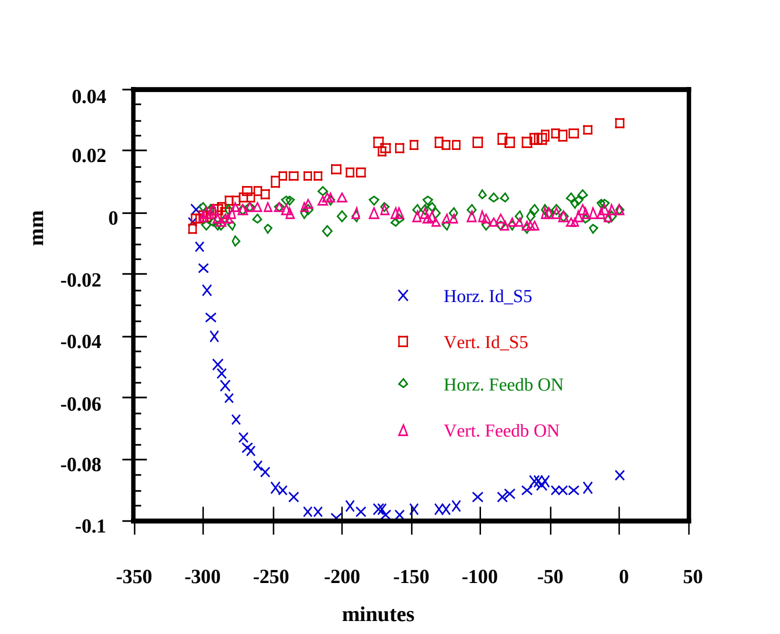
In red: A Beam Line spectrum with abrupt changes in the orbit

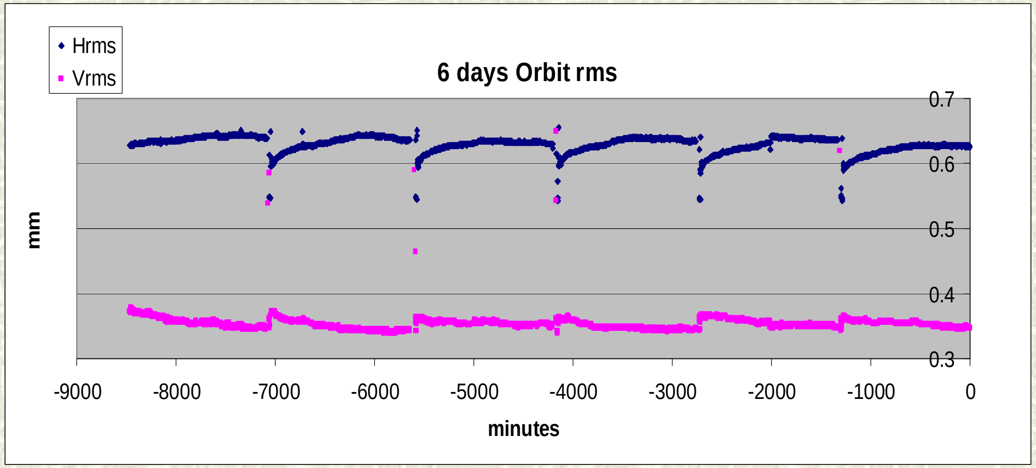
In blue: when corrections run smoothly

The Orbit at ELETTRA is influenced by

- Very slow ground thermal drifts
- Small ground settlements -> The machine will be shortly realigned
- Hysterisis effects due to mismatch between injection (1 GeV) and operation (2 and 2.4 GeV) energy (Ramping)
- Thermal load at 2 GeV on the vacuum vessel produces an up to 100 horizontal and up to 30 μm vertical orbit shift in the straight sections within 2 hours after the end of ramping
- Vibrations and mains noise up to some tens of Hz
- Maintenance and too often opening up for new installations
- ID strength / phase changing when the calibrations of the correction coils are no more valid -> comparable to thermal drifts

Biggest effect is the thermal load on the chamber



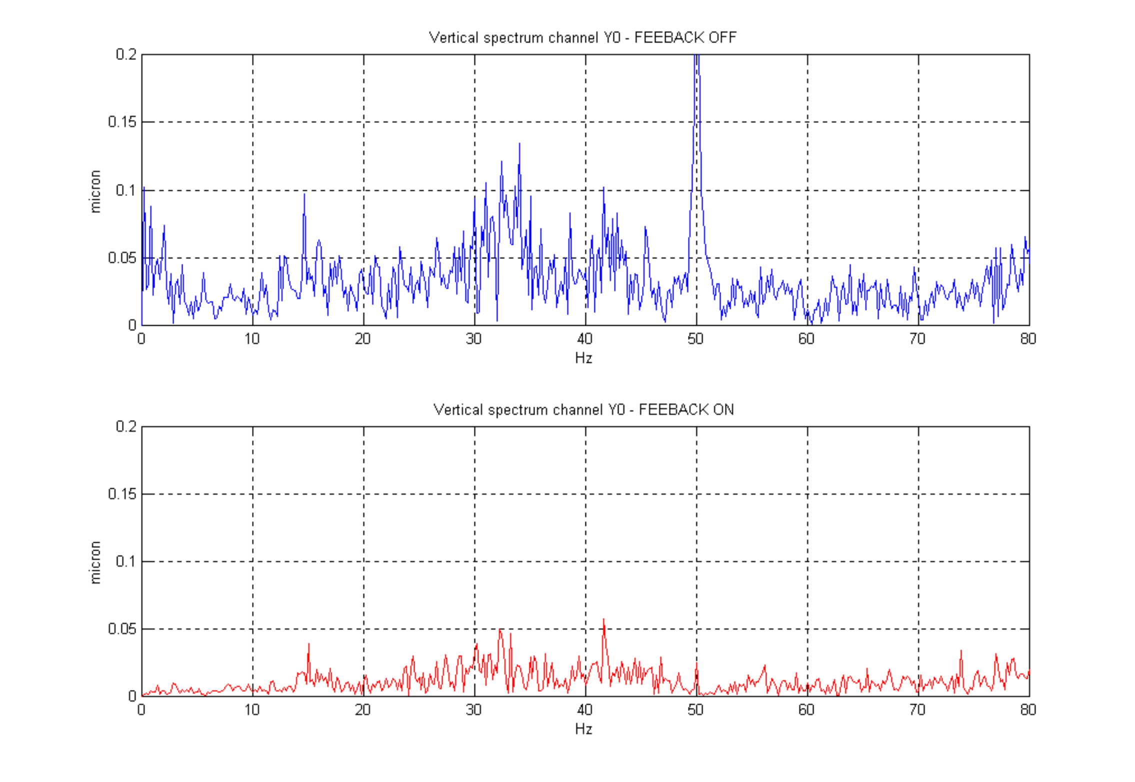


Worst case local orbit drift for a period of five hours without any feed back at 2 GeV with an initial current of 320 mA. Drifts in angle are less than 9 μrad horizontally

The Horizontal Global orbit drift is about ± 30 μ maximum over 24 hours while the vertical one is ± 15 μ .

Slow drifts are about 10 μ for longer periods (weeks)

Beam low frequency spectrum



Vertical beam position spectra at the LG-BPM n.1 with local feedback OFF/ON using the PID regulator with one harmonic suppressor centered at 50 Hz. The rms of the position signal in the 0-80 Hz range is reduced from 1.24 μm to 0.2 μm. (From Commissioning results of the Low Gap BPM system D. Bulfone, R. De Monte, M. Ferianis, G. Gaio, M. Lonza)

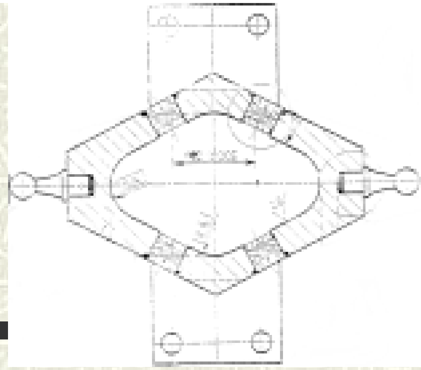
The detectors

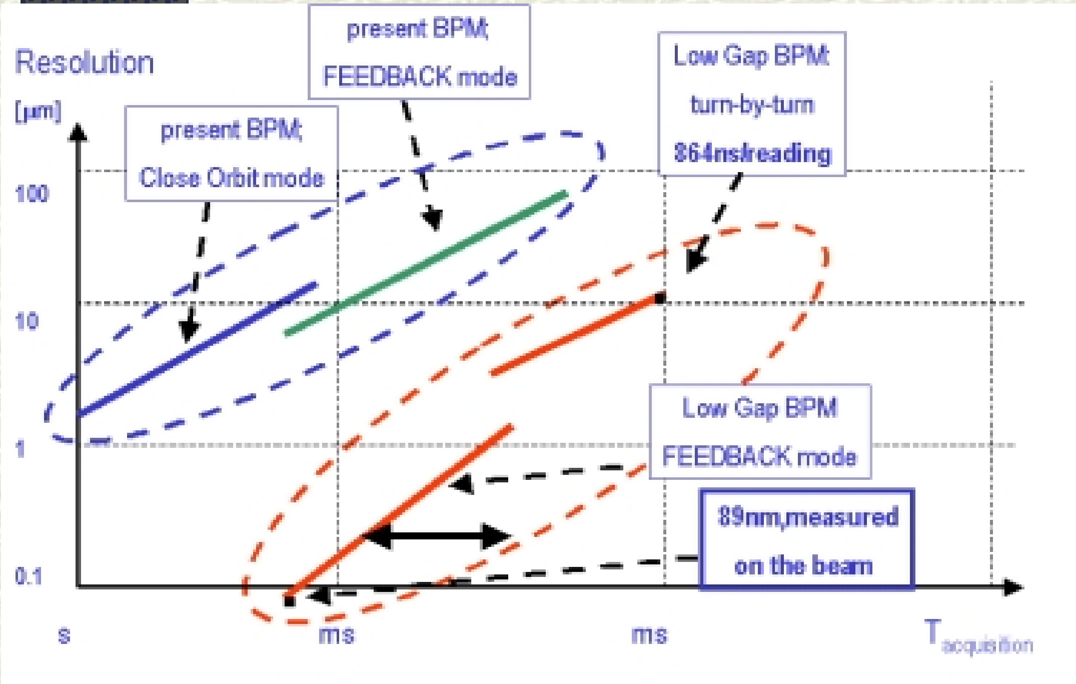
e-detectors: Until recently only 96 beam position monitors multiplexed with 150 μ absolute and 2.5μ relative accuracy (at 1 sec reading rate) attached to the quadrupoles. In practice the relative accuracy is compromised by longitudinal beam excitations to typically 5-10 μ

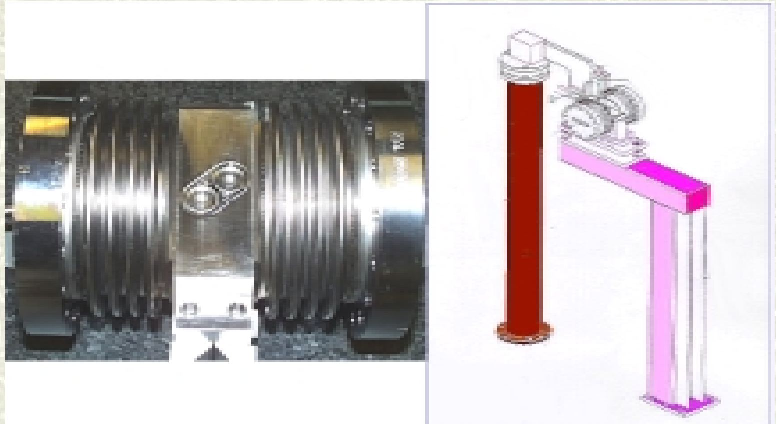
New high accuracy (sub micron) low gap beam position monitors that can be installed in pairs in straight sections using digital techniques and with their own independent support.

p-detectors: although high resolution digital, it was influenced by noise and bending magnet radiation that introduces a 10% error -> new design

e- beam position monitors



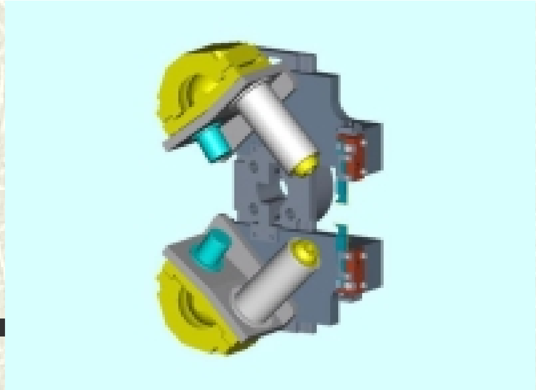




The Low Gap BPM with the two button electrodes and the two bellows and the LG-BPM support system, on the right hand side, with the Reference Column, on the left hand side.

Plot of the resolution (expressed in µm) vs. Acquisition Time (1/reading rate) for various beam position measuring systems: present BPM system at ELETTRA (blu dashed line), Low Gap BPM with Digital Detector (red dashed line). (courtesy M. Ferianis)

p-beam position monitors



At first were designed and installed traditional photon beam position monitors (PBPM) for insertion device (ID) beamlines only. Then, operational experience showed that these devices were not suitable for orbit feedback operations. So, in the last years a different approach has been taken working in two different directions. On one side a new design has been adopted for undulator PBPM and a first prototype has been successfully commissioned, while on the other hand PBPMs for bending magnet (BM) beamline have been also developed. In order to overcome the PBPM limitations, a new generation of PBPM for undulator is currently under development This novel detector has been designed to perform a drastic reduction of both spatial and energy integration with respect to the traditional device. It collects the information coming from a limited portion of the blade and from a small photon energy bandwidth centred on an undulator harmonic. This effect is obtained collecting the electrons photo-emitted by a set of blades hit by the photons. An electron energy analyzer, coupled to each blade, performs the energy selection over the electrons. A first prototype has been designed and built. Its commissioning is undergoing and its first results look very promising. The dipole radiation contamination has been cut off down to 0.1% as predicted. Moreover the position sensitivity has increased of a factor 2 due to the high selectivity in energy. This innovative device opens new perspectives for enhancing orbit feedback effects on the undulator beam stability. (courtesy A. Galimberti)

Correctors

The Beam Steering system consists of 82 combined H+V iron core correctors 0.22 m long with a 140-130 Gm maximum integrated field strength.

Additionally exists a number (2+2 for each group (max 3 and 2+2 for the electromagnetic elliptical wiggler) of flat IDs , 2+2 for each circularly polarizing id) of H and V coils to compensate the insertion device (ID) orbit effects of about a few Gm

Correction strategy

No Golden orbits

Every BL station is set to an optimal orbit position and angle

- Global corrections with in house developed programs (Gloc and Toca) usually **once per run**.
- Local orbit corrections with in house developed programs (slowFB and Orbit FB) usually once every 5 minutes.
- Fast local feedback up to 150 Hz and with 9 dB attenuation at 50 Hz -> the system was already functioning since 1998 but problems with the p-beam position detector kept it unused until now. (talk by D. Bulfone)

Correction strategy (cont.)

• Fast orbit compensation when the electromagnetic wiggler changes polarity in AC mode (up to 10 Hz) (talk by D. Bulfone)

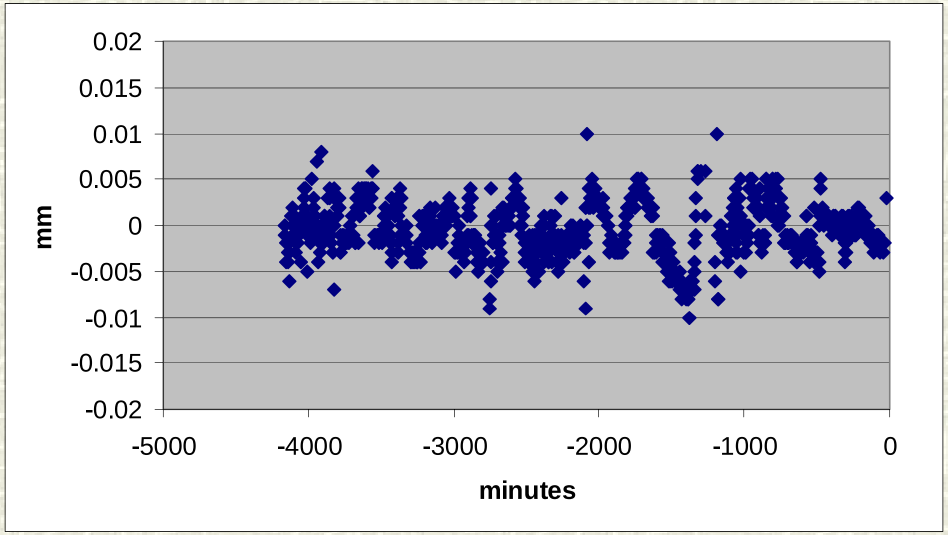
Using low gap BMP the fast local orbit feedback has been successfully used BUT

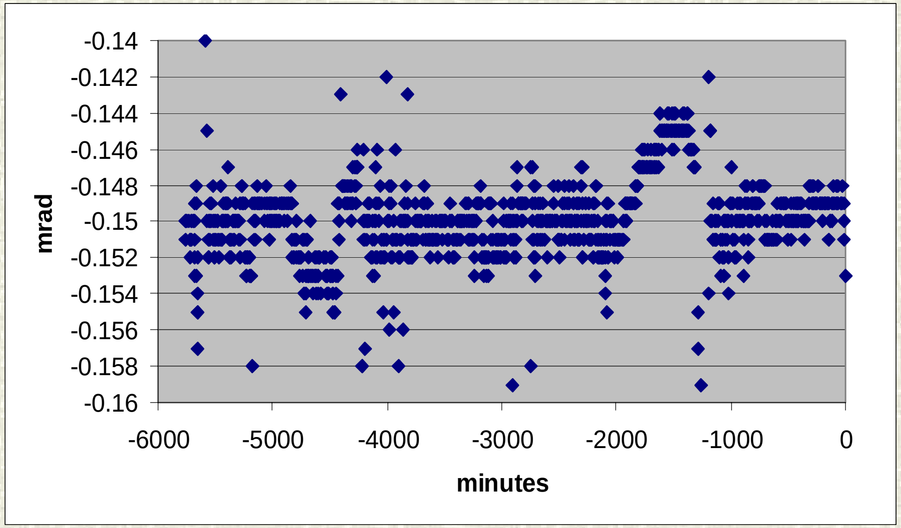
• Installation of such bpms in the machine will take a long time

• With the increase of the number of lines there is need for a global fast orbit correction scheme that will use all existing low gap BPM plus a selection of the old rhomboidal ones equipped with a signal splitter (so that their normal functionality will be intact) all with new digital detectors and rf front end electronics

Correction efficiency

At present the orbit is locally stable in the range of ± 5 µ and ± 2 µrad. Those numbers greatly depend on the detector and corrector efficiency.





But each station is set at a specific position and angle that maximizes the performance of the beam line.

Conclusions

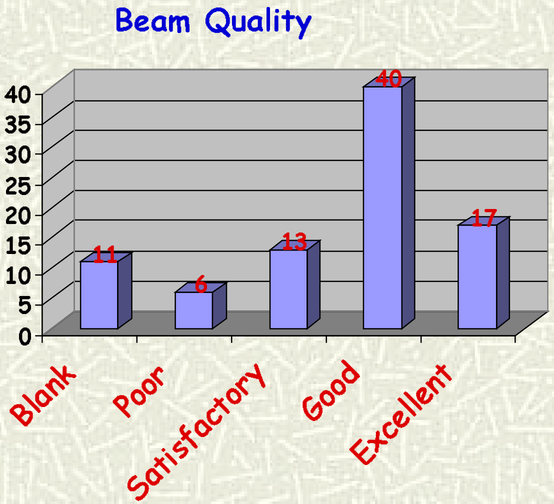
The present limits are good but not excellent. One needs to go towards sub-micron accuracy at the source point. However with the up to now available detectors and stability margins we were able to fully control the orbit mainly based on algorithms and software.

20% excellent

45% good

15% satisfactory

7% poor



This is what users think in general Particular comments about the orbit stability was that it is occasionally noisy (1-100Hz) with some abrupt position changes.

Discussions

With the new developments in the detectors the orbit stability will improve and with the up coming of the full energy booster the ring temperature will be kept stable (our biggest problem).

Thus we hope to be able to correct in the sub micron range soon anyway.

The fast local orbit feedback will be soon operational eliminating systematic fast orbit distortions or noise up to 100 Hz .