FEED-FORWARD CORRECTIONS FOR INSERTION DEVICES AT THE SLS

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The correction scheme for the kicks and deviations produced by not perfectly matched Insertion Devices (ID) is presented. Beside the global feedback these well localized distortions shall be corrected locally. However, to determine the strength for the correction magnets, the same algorithms are used as for the global feedback based on the beam dynamic code TRACY.

INTRODUCTION

Insertion Devices have to satisfy two requirements: when changing photon energy or polarization they have to behave transparent to the closed orbit as well as to keep the photon beam direction stable, important especially in the micro-focus beamlines. During the magnetic optimization in the laboratory most effort is made to achieve a straight trajectory with a small phase error allowing the high harmonic operation for high photon energies and, second, a low multipole content, i.e. a small band for the transverse variation of the first integrals respectively kicks of the electron beam. The kicks and offsets of the central trajectories are reduced but still do not meet the experimental needs.

For in situ corrections any ID is equipped with one or two pairs of correctors for the horizontal and vertical plane on every side. In addition every ID is equipped with beam position monitors (BPM). These monitors whose readout is based on analogue electronic from Bergoz are exclusively used for the machine interlock and local diagnostic and are not part of the global orbit correction.

While the permanent magnet IDs have external correctors enclosing undulator plus BPM, the electromagnetic undulators have correction coils on the two outer poles in the entrance sections which means within the BPM. The systematic saturation effects in these matching sections, i.e. the field dependent discrepancy between the required 1/4, -3/4, 1 increase in the field and in the current settings, are treated as normal errors.

Because of the very good field quality over the entire gap range the 6S in-vacuum undulator can be operated without any corrector.

straight	type	variability	no. corr
4S, 6S	single	gap	4
7M	single	gap + shift	8
9L	twin, elm	Iv, Ih, quasi-periodic	2 x 8
11M	twin	gap + shift	2 x 4

Table 1: Setup and operation modes of the IDs.

CORRECTION SCHEMES FOR CLOSED ORBIT

In a first step the IDs have to be made transparent and because of the many operation modes where up to two two-dimensional correction tables per single ID are needed the procedure to find the gap and shift dependent corrections has to be automized. As the trajectory has been optimized very carefully the distortions of the IDs can be assumed to be located at the entry and exit only. The correction strength for the correction magnets enclosing the ID are calculated by measuring the kick strength from the closed orbit response and finding the settings by matrix inversion [1]. The implementation is as follows: after a reference orbit is measured, the magnetic field in the ID is changed a certain margin. The correction current is calculated and immediately downloaded to the correctors. The difference to the reference is measured and iteratively optimized in 4 cycles (see Fig. 1). The correctors are switched off again and the same procedure is carried out for a whole gap range or a 2-dim table of settings. The whole measurements are done without feedback but using a warm machine and in the top-up operation mode the beam is very stable. The generated look-up tables are smoothed by polynomial fits and the correctors are linked to changes in their IDs.

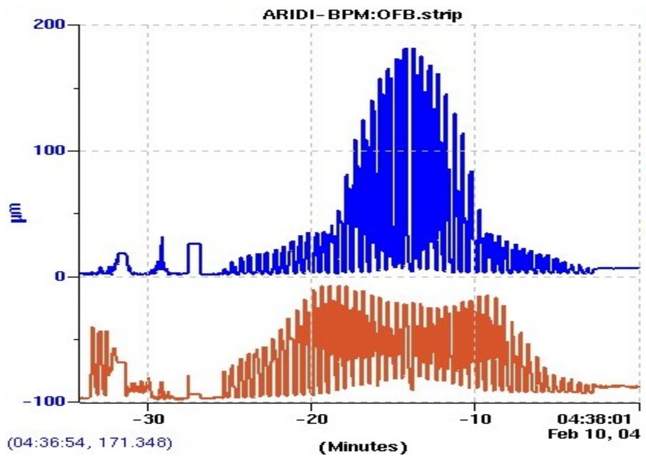

Fig. 1: Response of the rms value of the storage ring rf-monitors in x and y direction during feed forward calculation of the electromagnetic undulator UE212. Setting the calculated corrections in every step brings the rms value back close to zero.

In several steps the algorithm has been improved:

1) Because in case of the electromagnetic undulators in straight 9L by using only one corrector on each side the correctors reached their current limit, the use of two correctors has been implemented. As the use of two correctors allows for correcting kick and offset two correctors have been optionally implemented also for the permanent magnet IDs. Most correctors are combined magnets of the window frame type providing vertical and horizontal correction in one magnet. Due to the lack of space the single IDs and the 11M ID have only one corrector pair per plane. In these cases virtual correctors, i.e. the next following correctors in the arc, are used, but for the calculations only. The idea behind is that the global feedback will detect the resulting kick and will set the appropriate current automatically. This is because during the use of the fast orbit feedback there is no access from the control level to the ring correctors.

2) It has been observed that in spite of using the correctors the photon beam is still steering and deviations of the electron beam in the Bergoz BPMs can be observed. Therefore, as an additional constraint the read-out of the Bergoz BPMs shall be kept constant. This mode is running for 11M, but the corrections are not used so far. For 9L it has not been tested yet successfully.

3) So far with any new implementation the calculation for the corrector strength started from scratch. The code has been changed to use iteratively the previous results – from the first cycle or from the current settings - as the reference values. This seems to be important to reduce hysteresis effects in the iron yokes. Especially the 9L correctors follow in operation the fixed cycle of the ID and are not oscillating between zero and the set value as used in the original algorithm. From the other correctors only those of the wiggler in 4S follow all the time a fixed curve because this device is normally only opened and closed to the minimum gap. All other correctors have to follow the energy and polarization settings given by the user.

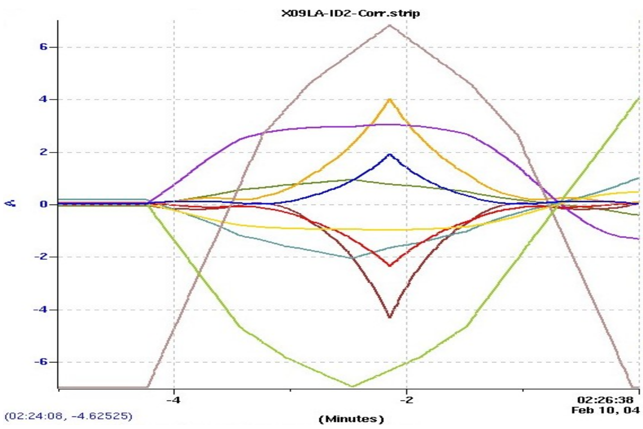

Fig. 2: Calculated corrector settings in case of the 9L electromagnetic undulator UE212 for a vertical field scan. Measured and implemented is a fit function whose parameters depend on the horizontal field. The quasiperiodic field variation to suppress integer harmonics takes places only in the periodic parts of the undulators showing only very small steering effects which do not have to be corrected.

The distortion of the closed orbit of the storage ring is reduced significantly. Still, transients are observed using the slow orbit feedback running with 0.3 Hz, which results in reduced speeds for gap, shift or current changes of the IDs. Not all improvements have been implemented so far or could be tested simply due to lack of commissioning time. So there is room for further improvements. The most problematic point was so far that the measurements were single user experiments with heavily shaking the beam. The implementation of the iterative algorithm could allow parasitic use of the beam for other users when optimizing the IDs.

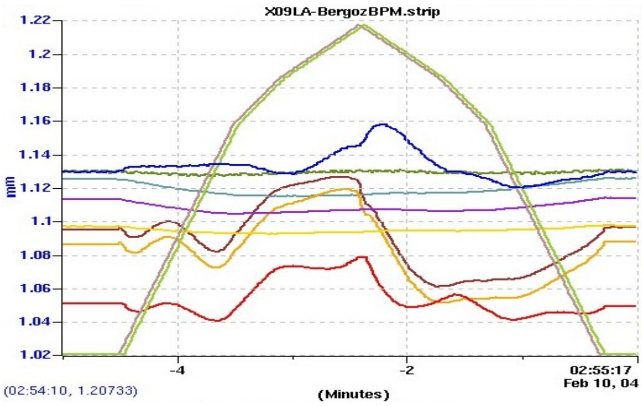

Fig. 3: Electron orbit distortions measured from the Bergoz BPM monitors within the corrections coils. The closed orbit is much less distorted and in operation with the slow orbit feedback only transients are left when the speed of a cycle of the undulators hysteresis loop is low, so far limiting the speed of photon energy variations. With the fast orbit feedback operating since December 2003, new settings can be set without speed limit. The steering seen by the monitors has to be minimized using also photon beam informations.

CORRECTION SCHEMES FOR PHOTON BEAM

Making the IDs transparent to the machine and other users is only one aspect. To stabilize the photon beam the recently commissioned x-ray monitors in the beamline front ends and sometimes special position chambers in the end stations (10 m respectively 30 m from source point) have to be taken into account. Based on the corrector settings from the described procedure, local closed bumps have to be set to keep the photon beam on the sample. The performance of these monitors is discussed elsewhere in this annual report [2]. The Bergoz BPM can measure the position of the electron beam but the x-ray monitors are very angle sensitive. The Bergoz BPM can still be optimized by matching their sensitivity to the individual geometrical dimensions of the different vacuum chambers and by increasing the ADC.

In summary, it is a fair statement that it is essential to be transparent to the machine and other users but not sufficient. Work is in progess.

REFERENCES

[1] A. Streun, *Calculation of insertion device feed forward tables*, SLS note 2002.

[2] J. Krempaski, *Insertion Device photon beam studies with X-ray monitors*, PSI Scientific and Technical Report 2002.