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INSERTION DEVICES IMPACT ON SOLARIS STORAGE RING OPTICS

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Abstract

Solaris storage ring is currently operating with three insertion devices. The IDs installed are the APPLE II type elliptically polarised undulators (EPU). The UARPES beamline is operating with the long period length EPU of 120 mm (EPU120) which has a significant impact on the linear optics and tune shift. The linear optics compensation of the EPU120 impact is realised by local adjustment of SQFO quadrupole/sextupole focusing gradient and defocusing gradient in the flanking dipoles. Two additional EPUs with period lengths of 58 and 46.6 mm are recently installed for next beamlines PHELIX and DEMETER, respectively and are under commissioning now. To reduce the impact of all undulators movement the additional correction coils are installed and the correction feedforward tables has been determined experimentally. Additionally to keep the tune at the nominal values the tune feedback is planned to be implemented. Within this presentation the effect of all existing insertion devices on the linear optics based on measurements and simulations to be discussed. Moreover the nonlinear effects, especially the impact on dynamic aperture of Solaris storage ring will be investigated.

SOLARIS STORAGE RING

The SOLARIS centre operates a compact third generation storage ring with parameters summarized in Table 1 below.

Table 1: SOLARIS Storage Ring Parameters [1]

Circumference	96 m
Current	500 mA
Energy	1.5 GeV
Harmonic number	32
RF frequency	99.93 MHz

INSERTION DEVICES

Currently SOLARIS operates with three insertion devices, as shown in Table 2 below. All insertion devices are APPLE II type elliptically polarizing undulators and each of them is equipped with a set of correction coils.

Table 2: Insertion Devices

Beamline	Period Length	Min. Gap	Manufacturer
BL04ID	46.6 mm	18 mm	ADC
BL05ID	120 mm	20 mm	KYMA
BL06ID	58 mm	14 mm	KYMA

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ORBIT DISTORTION AND CORRECTION

The most easily visible effect of insertion devices operation is beam orbit distortion. It is also the effect that is the most disruptive for the experiments.

Correction Method

Each insertion device is equipped with a set of eight correction coils operating as four independent channels. The coils are arranged diagonally on both sides of the magnet array, near the entrance and the exit of the insertion device.

The correction is realized by the software server which subscribes to undulator position change events and on each such event calculates correction coil currents from a correction table.

The correction table is measured beforehand, usually after each shutdown. The measurement is automated and takes around 20 h for each insertion device. As the gap closes, the density of measured points increases. This is done to shorten the measurement time, while still providing expected correction accuracy.

The measured coil response matrices are then decomposed using the SVD algorithm and used to calculate expected coil current value for given position. During operation tables containing those values are interpolated to fit current position of the device.

This unified system serves all three undulators at SOLARIS and is also planned to be used for the superconducting wiggler that will be installed in future.

UARPES and PHELIX Undulators

The effect of the UARPES and PHELIX undulators can be seen on Figs. 1 and 2 respectively. The sequence of movements is as follows:

- Close gap to 80 mm;
- Move phase: $-0.5\,\lambda \rightarrow 0.5\,\lambda \rightarrow 0\,\lambda$;
- Close gap to 20 mm (14 mm in case of PHELIX);
- Open gap to 200 mm.

The beam position is observed by XBPM monitors of the XAS (BL04BM) beamline frontend.

First pass is done with correction off. Total peak-to-peak oscillation from the orbit axis is about 150 µm for PHELIX undulator and exceeds 200 µm for UARPES.

Second pass is done with correction on and the oscillations have been reduced to under 20 µm in both cases. In case of UARPES and PHELIX the system is fully commissioned and used daily for user operation.

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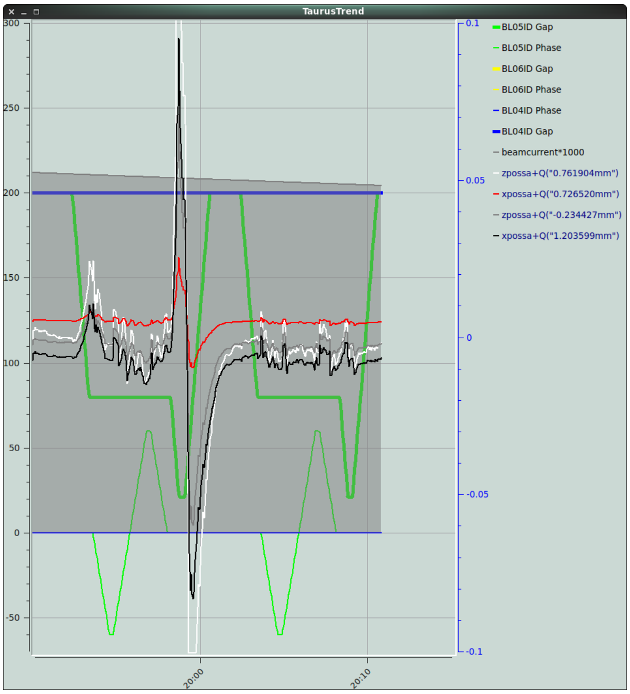

Figure 1: Effect of UARPES undulator movement without and with correction.

Figure 2: Effect of PHELIX undulator movement without and with correction.

DEMETER undulator

The DEMETER undulator was delivered with a set of hand-made looking correction coils mounted around the magnetic structures. The coils were shorted in several places and the overall quality and performance of the system was not satisfactory. The undulator recently received a set of upgraded correction coils using design and geometry similar to ones found in KYMA undulators. During testing it was revealed that also the power supply system was faulty. Originally the undulator used unipolar power supplies with custom polarity switching boards. After successful tests it was decided to replace this power supply system with CAENels power supplies, analogous to ones used in other undulators. The test correction table performance can be seen on Fig. 3 with the first three movements performed down to 50 mm and the last one to 25 mm. First movement is a control one, with no correction. Following two are corrected with scales −0.5 and −1.0 respectively. Last one is again with scale −1.0 as it was performing the best. It can be seen that on lower gap the accuracy greatly decreases. The test was done with short and low-density table and the performance is expected to increase when a full size table is available.

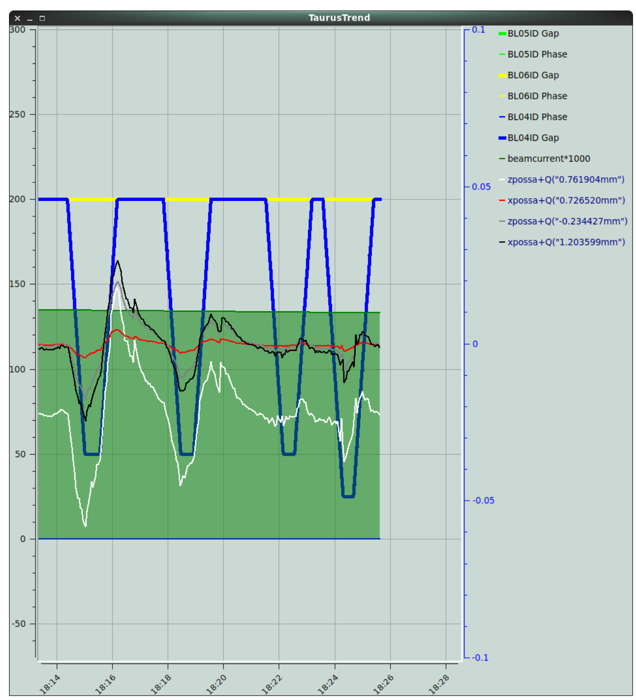

Figure 3: Test of new power supplies for the DEMETER undulator.

TUNE SHIFT

Another example of undulator influence is the vertical and horizontal tune shift. This effect is visible for low gaps, below 30mm. As it is not big in magnitude there is no correction done at the moment. The UARPES undulator shifts both the horizontal and vertical tune by 0.0045 (see

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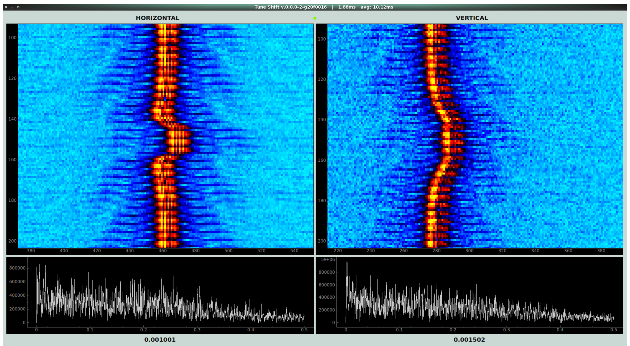

Figure 4: Effect of UARPES undulator movement on horizontal (left) and vertical (right) tune.

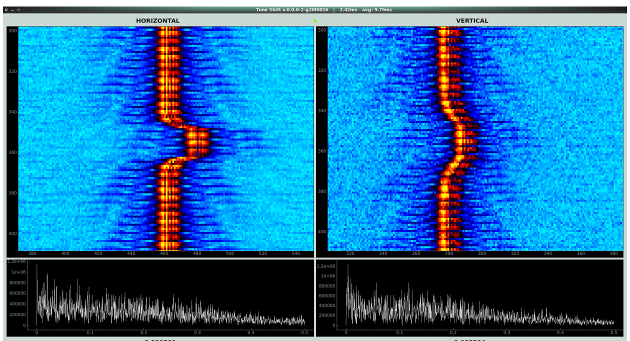

Figure 5: Effect of PHELIX undulator movement on horizontal (left) and vertical (right) tune.

Fig. 4). For PHELIX undulator horizontal shift is 0.0075 and vertical is 0.0055 (see Fig. 5).

Tune signal on the images has been captured during undulator closing to its minimum gap, 20 mm for UARPES and 14 mm for PHELIX, and then opening again.

FUTURE PLANS

Future plans involve improving the insertion device correction performance as well as construction of new devices. Tune control loop using local SQFO magnets is planned to be run along the correction system (see Fig. 6).

Commissioning of the fast orbit feedback system is also in progress. This will allow for correction of distortions coming not only from insertion devices with bandwidth up to 10 kHz.

In 2022 the SOLCRYS hard x-ray beamline that will use superconducting wiggler as a source will be commissioned.

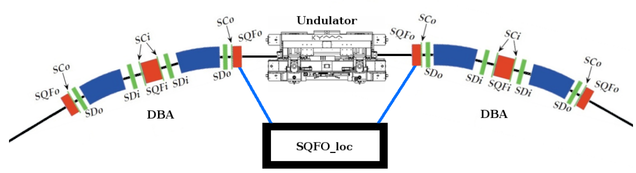

Figure 6: Connection of flanking SQFO magnets to power supply.

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[1] C. J. Bocchetta *et al.*, “Project Status of the Polish Synchrotron Radiation Facility Solaris”, in *Proc. 2nd Int. Particle Accelerator Conf. (IPAC’11)*, San Sebastian, Spain, Sep. 2011, paper THPC054, pp. 3014–3016.