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Calculated Shims' Signatures with the 17.2 mm Period New Undulator

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Abstract

In order to prepare some proper shims for the tuning of the upcoming new 17.2 mm period undulator, an investigation on the shims' signatures with the device was done. The right dimensions of some typical shims were decided based on the calculation results for this device's tuning. The detailed calculations of the shims' signatures will be reported in this technical note.

Introduction

The 17.2 mm period hybrid planar undulator is expected to produce an effective field of about 3400 G with its minimum gap of 10.4mm. This field strength is less than half of the regular undulator A (UnA) with the same gap. The shims that had been used for the regular undulators' tunings are expected to not be proper for the tuning of this short period undulator. Furthermore, from the mechanical structure point of view it has a confined side space compared to other regular undulators at the APS. That means applying the side shims that we have is not possible with this undulator. The side shims are very useful tools to change the field integral difference dramatically over all gap range for the tuning. Therefore, investigation needs to be done to determine if small side shims can or cannot create enough of a signature with this undulator. With this motivation, some typical shims' signatures were calculated in order to investigate the possibility of tuning when it is built in the near future.

Modelling and Calculation Results

A 16 period long model of the 17.2 mm period undulator was built with Opera 3D as shown in Fig. 1. The magnet type is N42SH from Shin-Etsu Rare Earth Magnet. The poles' material is vanadium permendur for the model. The dimensions of the magnets and poles are set the same as in the design review of this undulator [1]. The bh-curve of the permanent magnet is set for the temperature of 25ºC, which is the same temperature at the storage ring at the APS.

Three types of Iron shims were applied on the model of the 17.2 mm device and their signatures were calculated. The shim dimensions in XYZ are:

1) 56 mm x 300 micron x 2.85 mm / type 1 (trajectory shim)
2) 8mm x 8 mm x 2.9 mm / type 2 (side shim)
3) 4mm x 8 mm x 2.9 mm / type 3 (side shim)

The red parts in Fig. 1 are the type 1 shims on the top and bottom jaws. The calculated signature of the shims (B_y field vs Z) with a gap of 10.5 mm is shown in Fig. 2. When we integrated the data of the vertical component of magnetic field B_y over Z in Fig. 2, it was only 26 G-cm. With UnA, the same type of shims, but with a 100 micron thickness, create a signature of about 30 G-cm [2]. Therefore, with the 17.2 mm period device, we need to apply 300 micron or thicker trajectory shims. However, the magnet recess is 500 micron only from the pole tip, which means the shims can be thicker than 500 micron.

The tuning has to be done over all opening gaps with the device. Therefore, the signatures of the shims have to be known over all opening gaps. Figure 3 shows the calculated signature of two type 1 shims over the gap range of 10 mm-30 mm. The overall feature of the calculated signature as a function of the gap is consistent with the measured signature of the type 1 shim, except for the magnitude. Since the signature becomes quite small with a gap of 30 mm (as shown in Fig. 3), the further calculations with a gap larger than 30mm are not necessary.

Next, 4 type 2 side shims were applied with the model of the 17.2 mm period undulator as shown in Fig. 4, and calculated with the By field over the length of the model. Figure 5 shows the calculated signature on B_y vs Z of the type 2 shims with a gap of 10.5 mm. The shims decreased the field of the pole that is applied on about 120 G as showed in Fig. 5. The first vertical field integral (J_{1y}) of 4 type 2 shims was 432 G-cm with the gap. Similarly, the J_{1y} of 4 type 3 shims was calculated with a gap of 10.5 mm. The result is shown in Fig. 5. It decreased the field of the pole that is applied on about 40 G only. The J_{1y} of the type 3 shims was 147 G-cm with the gap of 10.5 mm.

In order to tune the trajectory of the electron beam with the device, the signature of the 4 type 2 shims were calculated as a function of the gap in the range of 10.5 mm – 30 mm. The result is shown in Fig. 6. The signature decreased exponentially with the gap increasing. This feature is the same with the measured signature of a side shim with a UnA with the exception of the magnitude. Figure 7 shows the calculated signature of the 4 type 3 shims as a function of the gap. These shims were applied 4mm off from the pole's edges in X for the purpose of conveniently applying the shims with the real device. The calculation in Fig. 7 was made with Radia. The result was consistent with Opera with a 1% difference in the signature of J_{1y} of these shims. The signature of the type 3 shims also decreased exponentially with the gap increasing.

Conclusion

The signatures of some typical shims were calculated with the model of the upcoming 17.2 mm period undulator with Opera and Radia. The calculation results showed that a 100 micron or 200 micron thick long trajectory shim that we have for our regular UnA or other devices' tuning is not proper for the tuning of this short period device. It requires a 300 micron or thicker shim for the electron's trajectory tuning with this device.

Although this device allows only a confined space for the side shim application, it is fortunate that small side shims can create enough signatures for the tuning of electron beam trajectory. The device will be able to tune with the shims whose signatures are calculated in this report.

References

[1] M. Abliz, R. Dejus, J. Grimmer, E. Moog, "Advanced Photon Source Upgrade Design Review Report."
[2] I. Vasserman, "A Shimming Technique for Improvement of the Spectral Performance of APS Undulator A." LS-253, APS, ANL.

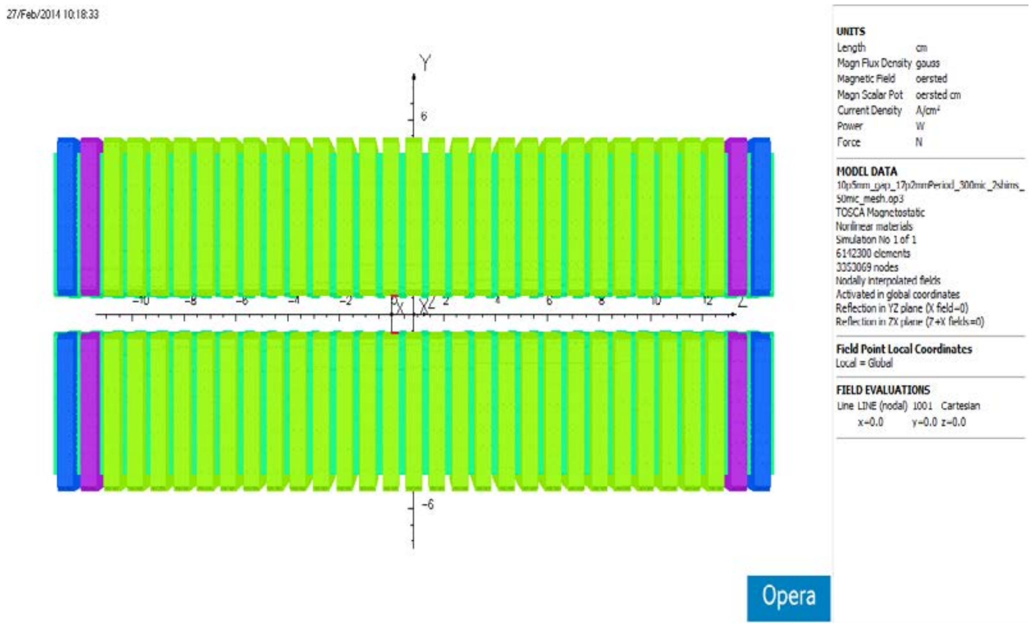

Fig. 1. The model of 1.72 mm period undulator. The wider pieces are the magnets and the narrower pieces are the poles. The red parts are the type 1 shims.

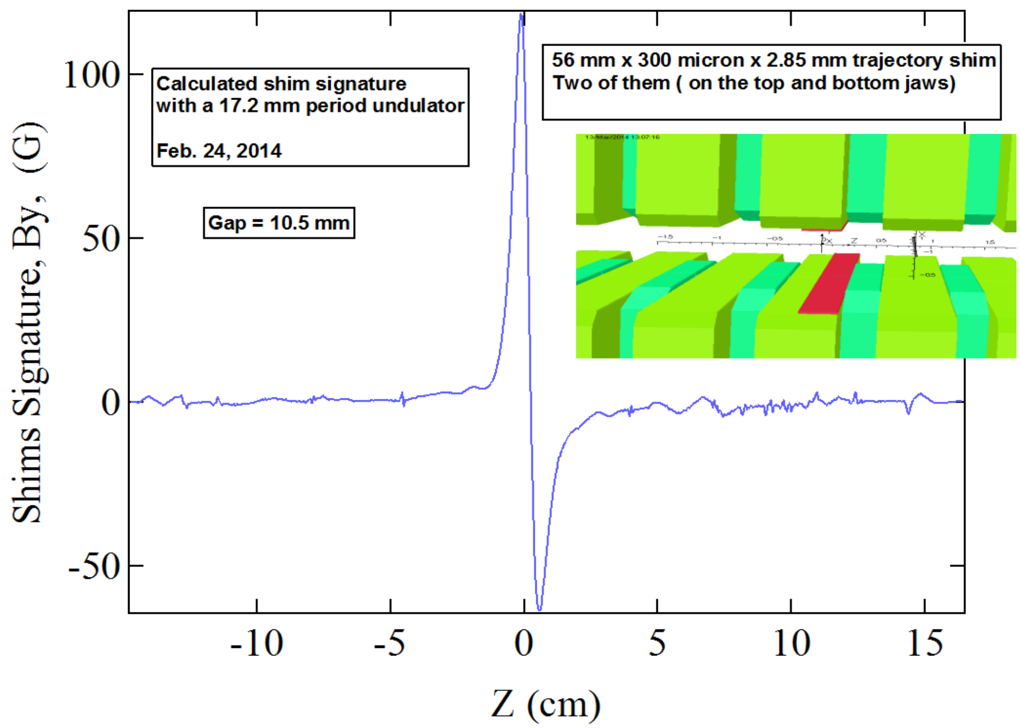

Fig. 2. The calculated By field that was created from the type 1 shims only over the length of the model. The insert is the enlarged picture of the model in order to see the location of the type 1 shims.

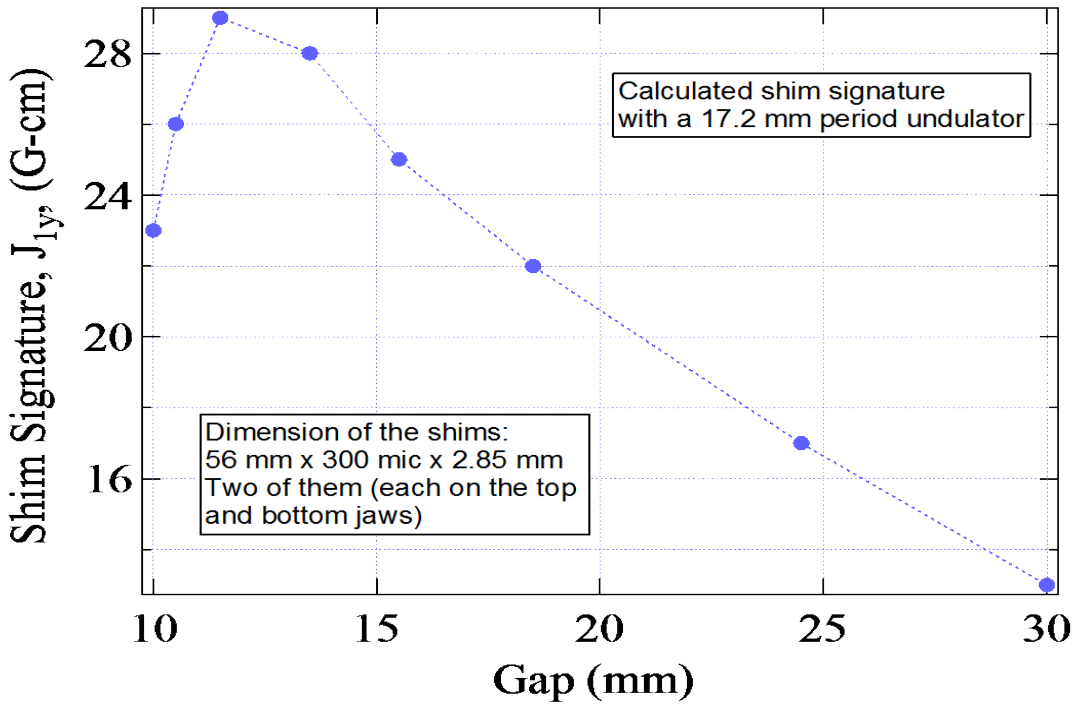

Fig. 3. The calculated and integrated signature of By field with the type 1 shims within the gap range of 10 mm – 30 mm.

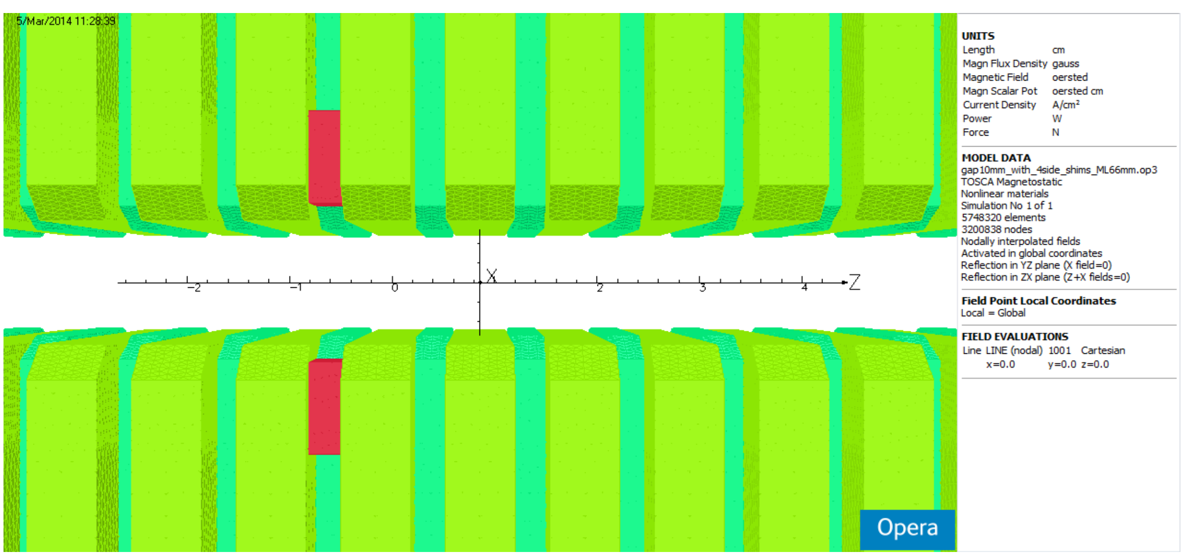

Fig. 4. The enlarged side view of the 17.2 mm period undulator model from – X direction with the side shims. There are two more of the same shims on the other side.

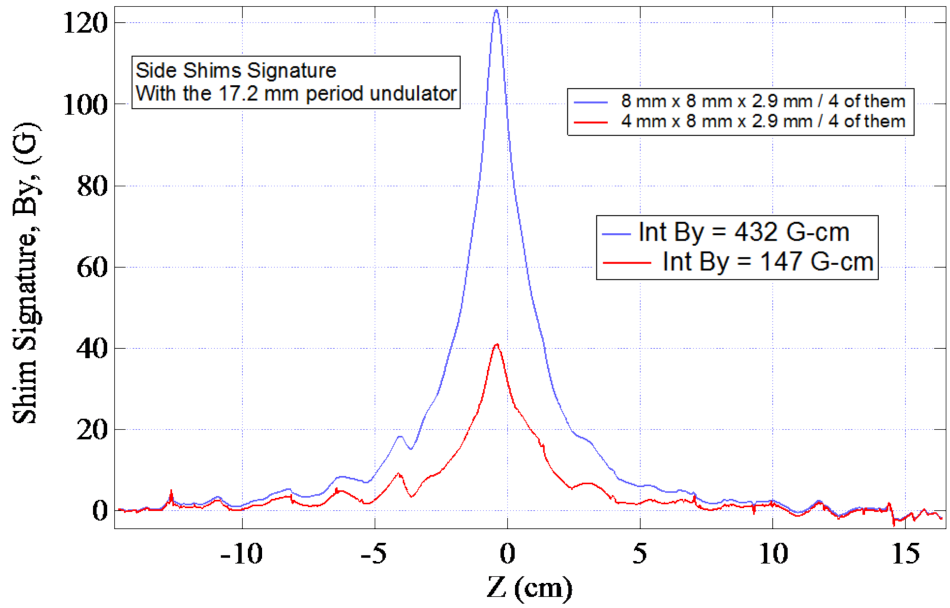

Fig. 5. The calculated By field that was created from 4 side shims only over the length of the model. The blue curve corresponds to the side shims with the dimension of 8 mm x 8 mm x 2.9 mm in XYZ. The red curve corresponds to the side shims with the dimension of 4 mm x 8 mm x 2.9 mm in XYZ.

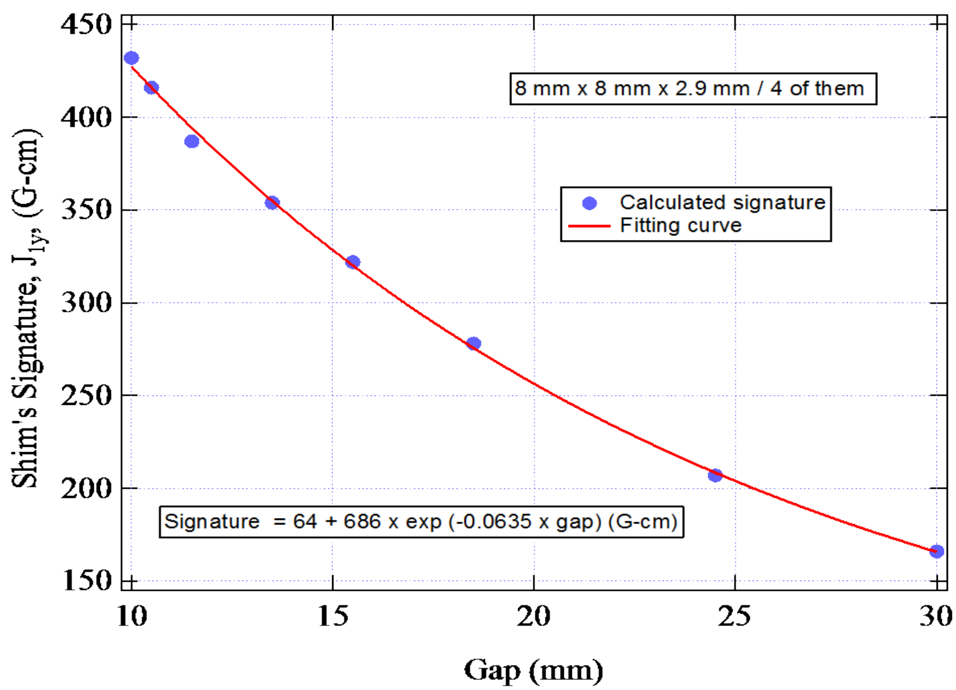

Fig. 6. The calculated signature of 4 side shims with a different gap from 10 mm – 30 mm. The dimension of the shims is 8 mm x 8 mm x 2.9 mm.

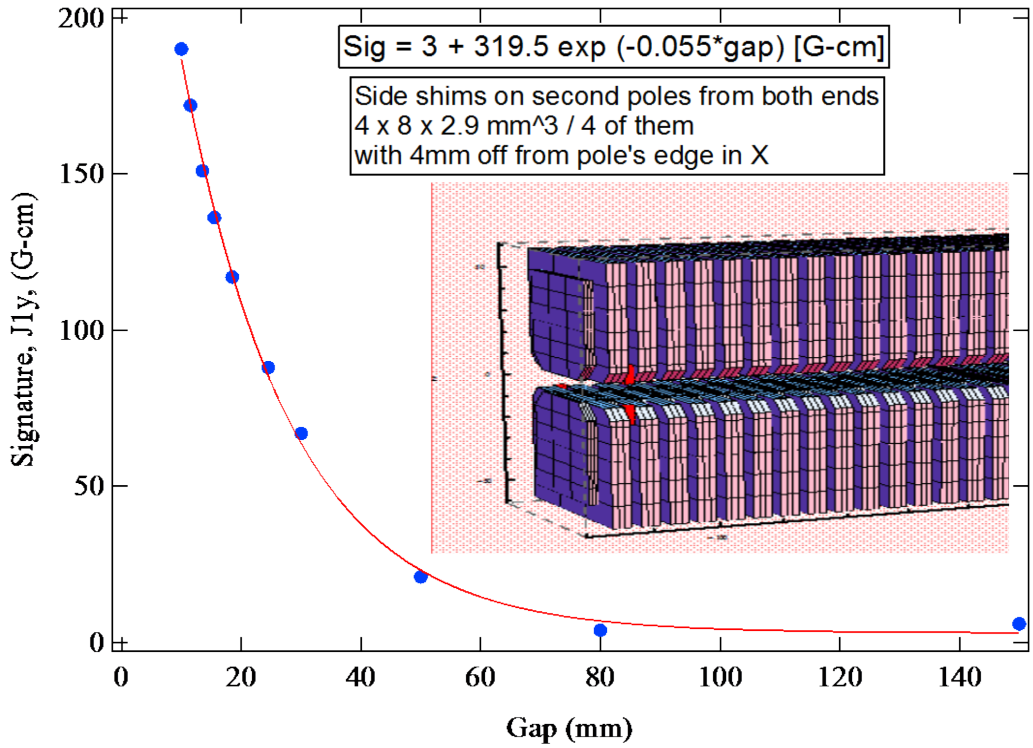

Fig. 7. The calculated signature of 4 side shims with a different gap from 10 mm – 150 mm with Radia. The dimension of the shims is 4 mm x 8 mm x 2.9 mm. The inserted picture is the model of the 17.2 mm period device that was built with Radia with the side shims on the second pole.