DAMPING WIGGLERS AT THE PETRA III LIGHT SOURCE

M. Tischer#, K. Balewski, DESY, Hamburg, Germany
A. Batrakov, I.Ilyin, D. Shichkov, A. Utkin, P. Vagin, P. Vobly, BINP, Novosibirsk, Russia

Abstract

We report on the progress in construction of damping wigglers produced at BINP for PETRA III. A series of 10 permanent magnet wigglers followed by SR-absorbers will be installed in each of the two damping sections. Thereby, the emittance of the 6GeV storage ring will be reduced down to 1nmrad. Prototypes of all major components have meanwhile been characterized and a test assembly of one complete wiggler cell has been performed successfully. The wigglers have a period length of 200mm and provide a peak field of 1.5T. Meanwhile, all of the 4m long devices have been fabricated and assembled. We present results of magnetic measurements and tuning.

INTRODUCTION

At present, the PETRA storage ring at DESY is reconstructed towards a 3rd generation light source [1] operating at 6GeV. One octant of the machine will be rebuilt completely and provide 14 undulator beamlines, the other parts of the ring will be refurbished to a large extent.

In two of the long straight sections of PETRA, damping wigglers will be installed in order to reduce the emittance down to 1nmrad. The wigglers will be placed in dispersion-free drift sections between quadrupoles and are followed by synchrotron radiation absorbers. 20 wigglers will be installed in total.

WIGGLER DESIGN

Design considerations and parameters of the 4m long permanent magnet wigglers have been presented earlier [2]. Table 1 summarizes the key parameters.

Table 1: Damping wiggler parameters

Peak field B_0	1.52 T
Magnetic gap	24 mm
Period length λ_U	200 mm
Number of poles	40 = 36 + 2 (0.75B_0) + 2 (0.25 B_0)

The fixed-gap wiggler is made of a hybrid structure with additional magnets at both sides of each pole. The magnet structure is fully enclosed by a soft iron yoke used as mechanical support and as an efficient mean to reduce the leakage magnetic flux. Wedge-shaped iron poles are used with a small recess in the central part, which helps to counteract the intrinsic sextupole contribution within half a period. The axial magnets are split into two 3cm long parts and are separated by a soft iron notch sitting on the yoke and serving as a zero potential plate. By that means, neighboured poles are decoupled to a large extent and therefore can easily be tuned independently by adjustment bolts creating a shunt towards the iron yoke. The adjustment range of about 400G (2.5%) reduces requirements on the quality of permanent magnets and allows using cost-efficient Chinese serial production magnets. The total weight of magnets bought for all wigglers was 7 tons. Magnet parameters are listed in Table 2.

Table 2: Permanent magnet parameters

B_R	1.32÷1.38 T
H_{CB}	1003 kA/m
H_{CJ}	1592 kA/m

MEASUREMENT METHODS

The damping wigglers are measured by three methods:

Vertical field mapping using Hall probes. A thermo-stabilized carriage is used with 11 transversely spaced Hall sensors. The distance between the sensors is 5 mm. The carriage moves inside the wiggler in beam direction with a measurement step size of 4mm. The longitudinal and transverse dependence of the vertical field are measured. All equipment for Hall measurements has been elaborated at BINP [3]. The absolute accuracy of field mapping is ±150µT within a range of ±1.6T.

Specialized software has been developed for this setup that represents the field map, 1st integral, their transverse profiles, and beam trajectory.

Stretched wire measurements. A filament wire with 30 strands is shifted in horizontal or vertical direction by a moving mechanism with 2mm step size. The induced voltage is integrated by a Volt-Second-to-Digital Converter (VsDC) during movement at each step. This results in the transverse distribution of the first and second integrals of the vertical or horizontal field. The return wire is motionless located inside the wiggler.

Specialized electronics (VsDC and low noise preamplifier) guarantees an accuracy of 3µTm (rms) for moving coil measurements [4]. The accuracy of these measurements for damping wigglers is 5µTm (rms). Special software was developed to control these measurements and process theirs results.

Horizontal field measurements by λ-coils. A ceramic holder contains 5 coils, spaced by 5mm to each other in transverse direction (Fig. 1). Thus, this 5-coil assembly measures the distribution of the horizontal 1st field integral and its transverse profile along the wiggler. The coils have a length of exactly the period length λ_U=200mm so that they average the field over one wiggler period. By that means, the vertical main field is highly suppressed.

#markus.tischer@desy.de

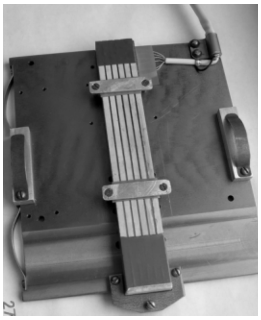

Figure 1: λ-coil.

The coils are moved through the wiggler in 2cm steps while the coil's output voltage is integrated by a VsDC. For each step, the output data represent a floating average value (over the coil length) of the horizontal field which is then integrated. The coil measurements have an accuracy of about ±20Gcm.

A view of the measuring assembly is shown in figure 2.

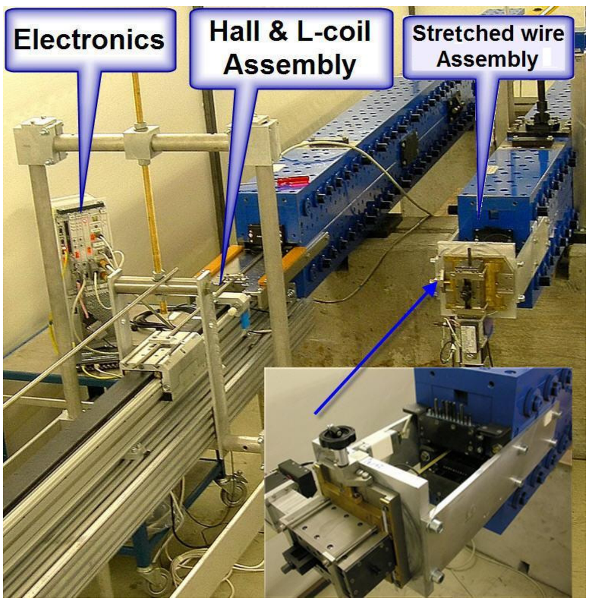

Figure 2: Wigglers on measurement test bench.

WIGGLER ADJUSTMENT

The wiggler tuning process included two stages: At first, the vertical field amplitude of each pole was adjusted by corrector bolts [2] and using the Hall probe measurement system. In the second step, horizontal and vertical 1st and 2nd field integrals were measured by the stretched wire system and adjusted using external finger correctors shown in Fig. 3.

Figure 3: Finger correctors.

The second integral was adjusted using correctors on the beam entrance side. Afterwards, the first field integral was adjusted using the beam exit correctors. For some wigglers, horizontal field integrals were too big to be corrected by finger correctors. In these cases, λ-coil measurements of the horizontal field integral were used to locate the poles where the field errors occurred. The horizontal field of these poles was then adjusted by tuning their horizontal position. Figures 4 and 5 compare the horizontal field distribution before and after correction.

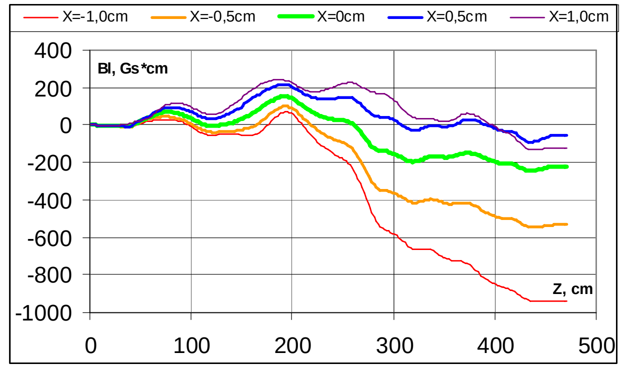

Figure 4: Horizontal 1st field integral along the wiggler for different transverse positions (x) before correction.

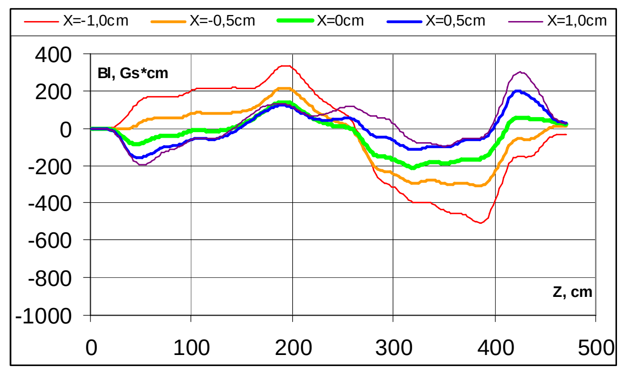

Figure 5: Longitudinal distribution of horizontal 1st field integral after correction at particular poles.

Due to lack of space, the vertical gap of the horizontal field finger correctors is three times larger than that for the vertical correctors. This complicates the finding of a correct finger signature for an optimal correction considerably. To make this process more efficient, field integrals were calculated for all fingers at various

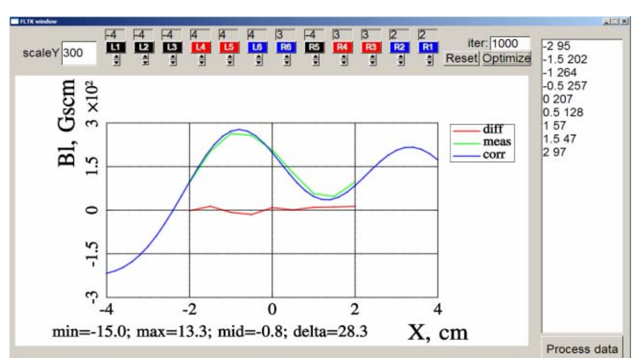

Figure 6: Transverse dependence of horizontal integrals: measured data (green), modelled signature (blue) for selected configuration on top (sign and strength), and expected residual (red) after correction.

magnet positions [5]. Superposition of different corrector signatures allowed to model any transverse field integral dependence and to find the appropriate configuration (Fig.6).

RESULTS

Figures 7–10 present the transverse dependence of 1st and 2nd horizontal and vertical field integrals of all wigglers. For most devices, the horizontal and vertical 1st field integral is within a range of ±50Gcm and ±30Gcm, respectively. Horizontal and vertical 2nd field integrals are within ±30kGcm^2. Note, that the total vertical 1st integral, produced by the 40 positive and negative poles, sum up to ±1,800kGcm.

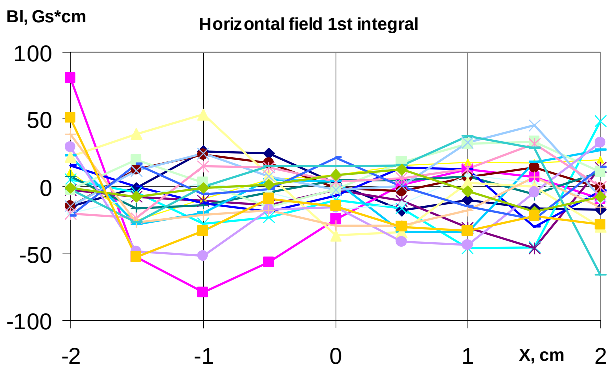

Figure 7: Transverse dependence of horizontal 1st field integral for all damping wigglers.

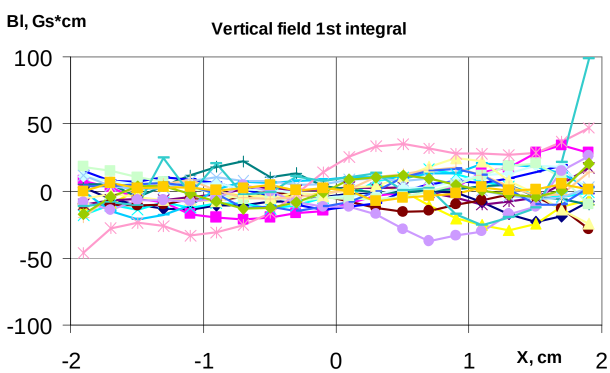

Figure 8: Transverse dependence of vertical 1st field integral.

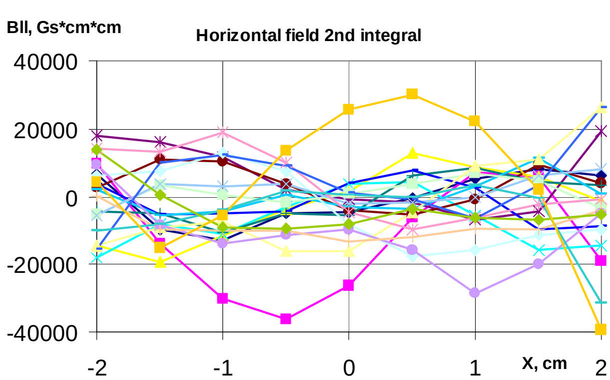

Figure 9: Corresponding horizontal 2nd field integral.

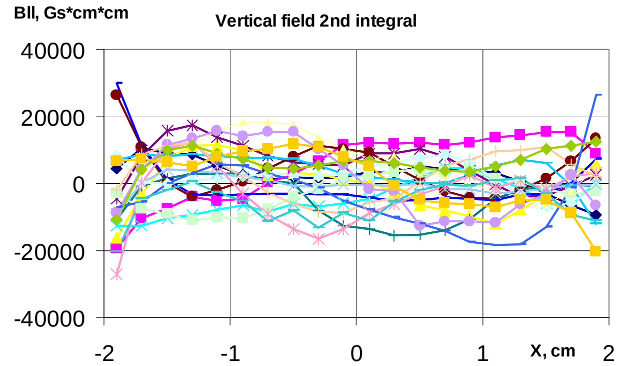

Figure 10: Corresponding vertical 2nd field integral.

TEST INSTALLATION

An assembly test with two wigglers has been performed in one of the damping sections (Fig. 11). A special appliance can be mounted at the wiggler to separate the two wiggler halves manually. In the opened state, the wiggler can be moved on the support unit over the vacuum chamber once the damping wigglers shall go into operation. It has been proven that the field integral measurements can be reproduced within about ±30Gcm after opening and closing the wiggler halves.

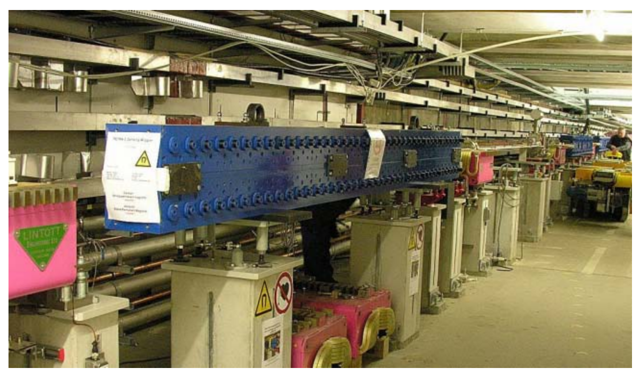

Figure 11: Damping wiggler test installation at tunnel.

REFERENCES

[1] K. Balewski, *"Status of PETRA III"*, these proceedings; http://petra3.desy.de

[2] M. Tischer et al., *"Damping Wigglers for the PETRA III Light Source"*, Proceedings of PAC, Knoxville, 2005, p.2446

[3] A. Batrakov, S. Zverev, I. Ilyin, et al., *"The new VME – based system for magnetic measurements with Hall sensors"*, Proceedings of RuPAC, 2006.

[4] A. Batrakov, V. Sazansky, D. Shichkov, P. Vagin. *"Hardware and software for magnetic measurements with movable coils"*, Proceedings of RuPAC, 2006.

[5] A. Dubrovin, *"Mermaid User's guide"*, Novosibirsk, 2006