5 T NON-SUPERCONDUCTING WIGGLER

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Abstract

At present at Budker Institute of Nuclear Physics the non-superconducting three pole wiggler is developed. The wiggler provides 5 T magnetic field in 20 mm pole gap with using permanent magnets and coils. Magnet design of the wiggler, its effect on electron beam dynamics of storage ring VEPP-3 and spectra of synchrotron radiation are described in given paper.

1. Introduction

The wiggler presents 3-pole shifter with 5 T peak field of the central pole and 1.5 T field of the side poles. Peak field provides critical energy of photons about 13 keV for 2 GeV electron beam energy of storage ring VEPP-3. The maximum field of 5 T is achieved by using combination of electrical copper coils and permanent magnets located on the central pole. Such combination allows to change field in wide range from less than 1 kGs up to 50 kGs with acceptable influence on electron beam dynamics.

2. Magnet Design

Picture of the wiggler is shown in Fig. 1. The central pole is surrounded by blocks of permanent magnets and copper coils. The central pole has taper shape in longitudinal and transverse directions. In longitudinal direction the pole edges lie on line going under 45^0 with respect to the center of the

Table 1. Wiggler magnetic parameters.

Maximum magnetic field	5 T
Pole gap	20 mm
Field in side magnet yoke	1.5 T
Minimum magnetic field	0.1 T
Remanence field of permanent magnets	13 kGs
Integral homogeneity at ± 1 cm	$5 \cdot 10^{-4}$

wiggler. Such a form of the central pole allows to achieve maximum contribution to field on wiggler axis from the pole steel, which is under strong saturation. The central pole is made of Permendur material with high level of saturation induction, that does increase the peak field. The copper coil has rectangular cross-section and is designed of copper bus with cooling channel. Its configuration and location are optimized in order to have maximum contribution to on-axis field and to facilitate fabrication. Permanent magnet blocks are located on the nearest position to the center of the wiggler so that to achieve their maximum contribution to the peak field. Upper part of the permanent magnet blocks serves for decreasing saturation of the central pole. The magnetization direction of permanent

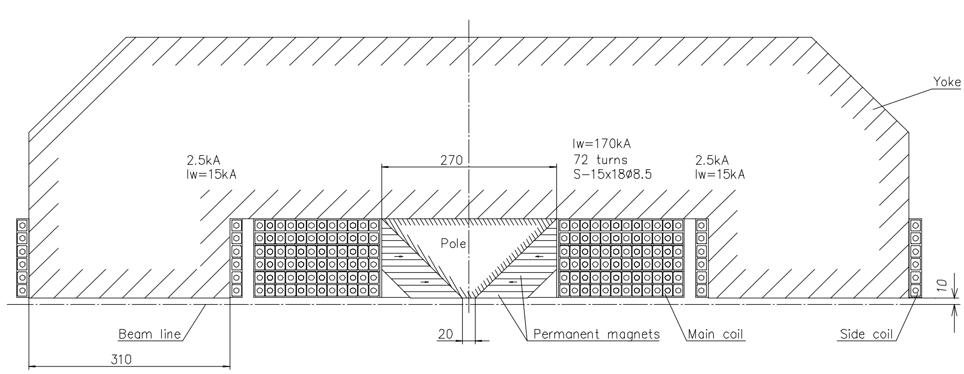

Fig. 1 Schematic view of 5 T wiggler (only upper part is shown).

Table 2. Wiggler design parameters.

Total length	1360 мм
Pole width in transverse direction	70 мм
Pole width in longitudinal direction	20 мм
Bus current	2500 A
Number of amper-turns	72
Dimensions of copper bus:	15×18, mm
Power: for 4.5 T peak field for 5 T peak field	55 kW 100 kW

magnets is parallel to horizontal plane and directed towards to the center of the wiggler. So there is no demagnetization of permanent magnet by general (vertical) component of magnetic field. The horizontal component of wiggler field does not increase 10-12 kGs and does not lead to demagnetization of modern permanent magnets. In transverse direction the central pole has width of 7 cm that is necessary to provide required homogeneity of magnetic field in that direction.

Feature of this type of wigglers is residual magnetic field at zero coil current due to permanent magnets. This field has non-zero integral and can be compensated by main or side coils. At low energy of electron beam it can lead to distortion of beam optics and necessity to compensate one. In our case the residual field does not increase 1 kGs and does not influence on beam optics.

The magnetic and design parameters are given in Tables 1 and 2 correspondently. Fig. 2 and 3 show the longitudinal and transverse distribution of magnetic field correspondently.

3. Wiggler influence on beam dynamics.

Table 3 presents the linear optics parameters of storage ring VEPP-3: original parameters, disturbed parameters due to the wiggler set up and parameters

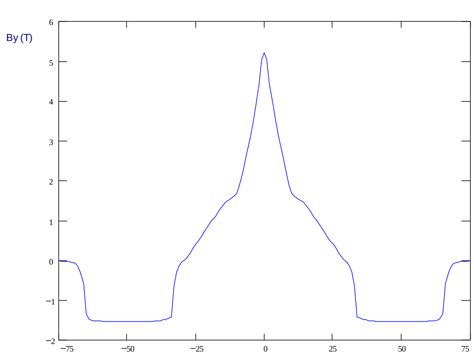

Fig. 2 Longitudinal distribution of magnetic field.

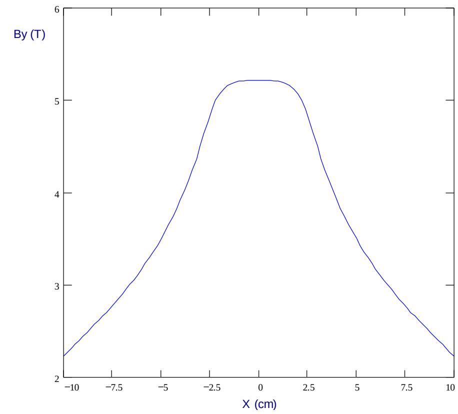

Fig. 3 Transverse distribution of magnetic field.

after the distortion compensation. As one can see the original and disturbed parameters differ for several percents. The distortion can be compensated by elements of the magnetic lattice according to power supply system.

Table 3. Linear optics parameters for storage ring VEPP-3

	Original lattice	Disturbed lattice	Compensated lattice
ν_X,	5.146753	5.127541	5.146748
ν_Z,	5.180953	5.196997	5.180948
β_X, m	3.718	3.57	3.733
β_Z, m	1.994	2.206	2.153
α_X	1.459	1.248	1.328
α_Z	-0.947	1.061	-1.047
η_X, m	0.847	0.787	0.848
$\alpha, 10^{-2}$	7.337	7.337	7.233
C_X	-5.185	-5.212	-5.233
C_Z	-6.069	-6.152	-6.183

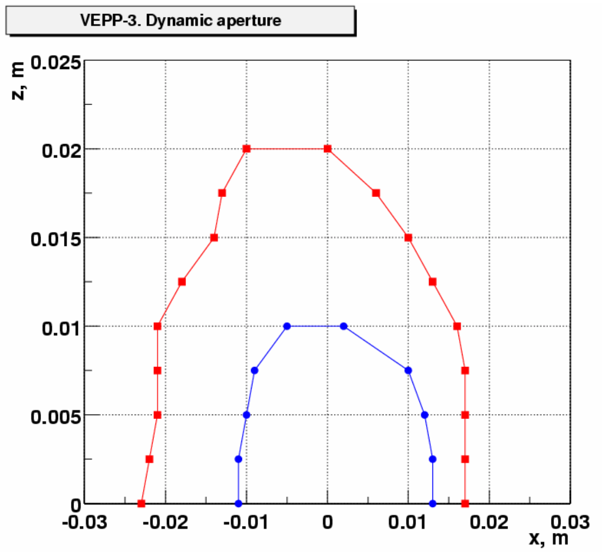

Fig. 4. Dynamic aperture for non-perturbed (external points) and perturbed (internal points) lattices of storage ring VEPP-3.

Fig. 4 shows the dynamic aperture for non-perturbed and perturbed lattices of storage ring VEPP-3. The 5 T wiggler essentially decreases the dynamic aperture, but it stays enough for normal work of machine.

At injection regime (low beam energy and low wiggler field) there is no essential wiggler influence on lattice parameters and optics does not need to be compensated.

4. Synchrotron radiation spectrum.

The maximum 5 T magnetic field corresponds to 13 keV photon critical energy. The energy distribution of synchrotron radiation power integrated over vertical angle and emitted in 1 mrad of horizontal angle is given in Fig. 5.

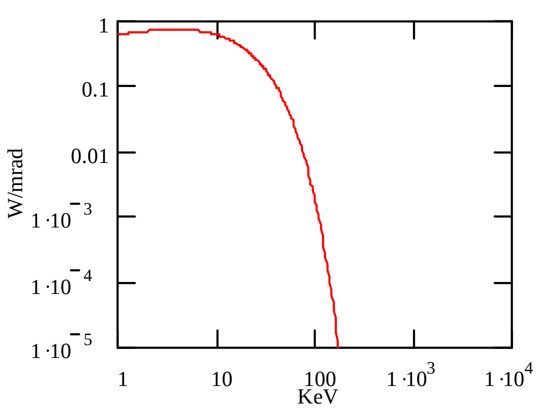

Fig. 5. The energy distribution of synchrotron radiation power integrated over vertical angle and emitted in 1 mrad of horizontal angle.

The maximum SR angle from wiggler is ± 75 mrad, maximum electron beam deflection is 30 mm.

5. Conclusions.

Creation of such type wigglers with high level of magnetic field opens new possibilities in using synchrotron radiation sources. In some cases this type wigglers can be used instead of superconducting wigglers, which are essentially expensive. Combination of copper coils and permanent magnets allows to change magnetic field (and photon critical energy) in wide range.

Such magnet design can be applied to bending magnets to form the dipole field with peak in the center of magnet and uniform field in its other parts (superbend). It will allow to have high brightness of synchrotron radiation from bending magnet and save emmitance non-perturbed.

6. Acknowledges.

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7. References.

1. “MERMAID”, BINP, Russia, Novosibirsk.