Magnetic measurements in small aperture of indirect cooling wiggler.

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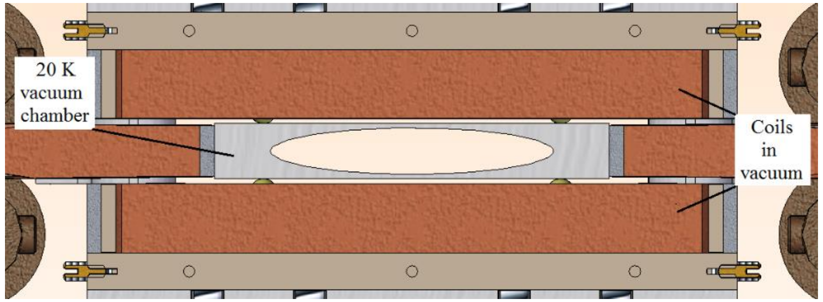
Several last superconducting wigglers fabricated in BINP are of indirect cooling. They all have small aperture with cryogenic temperature. This feature makes measurement enough complicated task. Magnetic measurement system designed especially for one of such wigglers are described in this article. The results of magnetic measurements both by Hall probe and by stretched wire method are also presented.

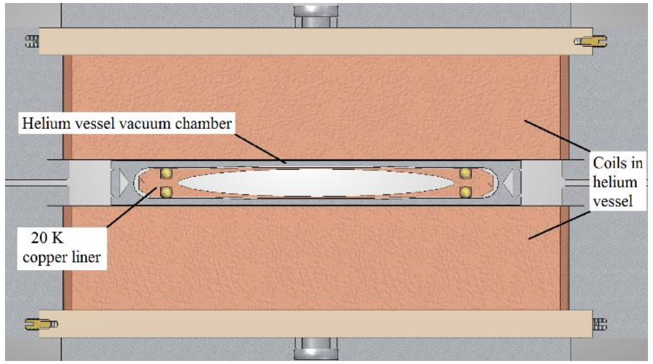
The last two wigglers with indirect cooling fabricated in Budker INP were wigglers for Kurchatov institute in Moscow. The main parameters of this wigglers are presented in table.

Total number of poles	54
Number of main poles	50
Number of side poles	4
Period	48 mm
Magnetic gap	14 mm
Nominal magnetic field	3.0 Tesla
Maximum magnetic field	3.6 Tesla
Currents in coils	370 + 400 A
Stored energy	10 kJ
Vertical aperture	10 mm
Horizontal aperture	60 mm

As can be seen from the table the aperture is not so small. However, it is necessary to take into account that the vacuum chamber with this aperture is enough cold. Its temperature is low than 20 K. This cold vacuum chamber located between wiggler coils being in vacuum. There is small gap between the chamber and coils.

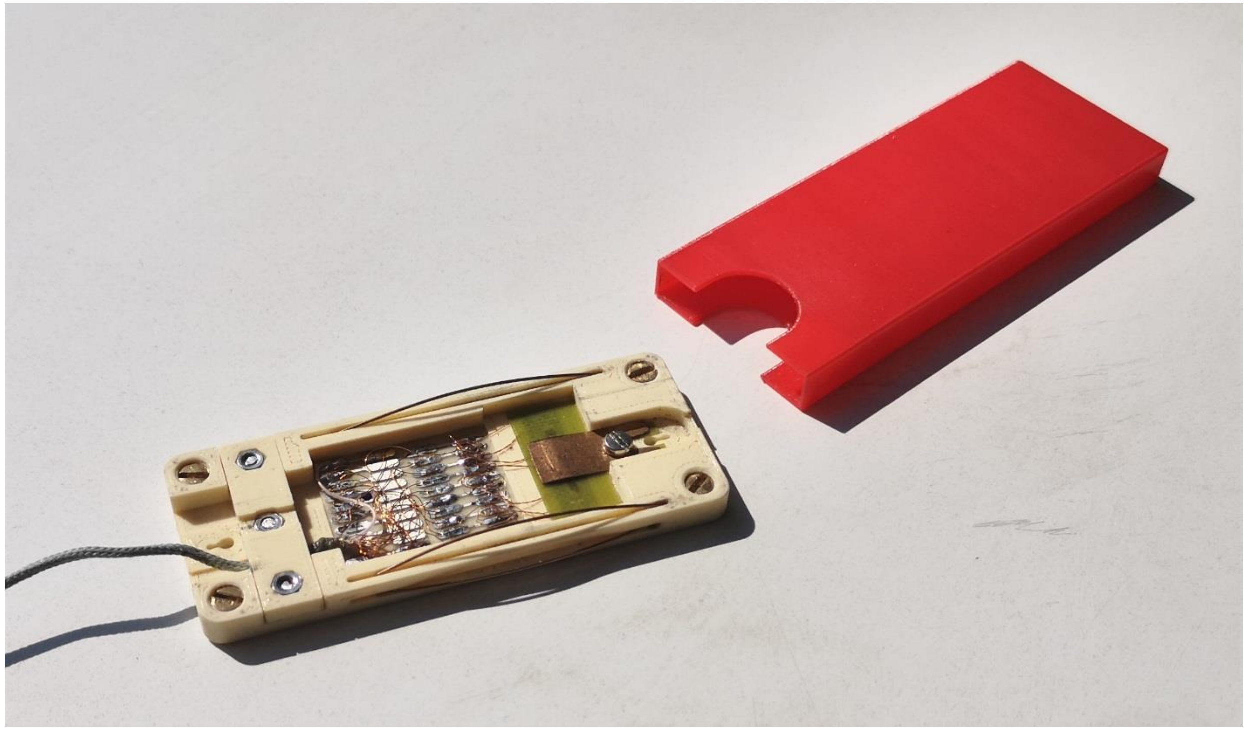


In wigglers with direct cooling coils immersed in liquid helium vessel so there is helium temperature vacuum chamber into magnetic gap. Copper liner with 20 K temperature inserted into cold vacuum chamber.



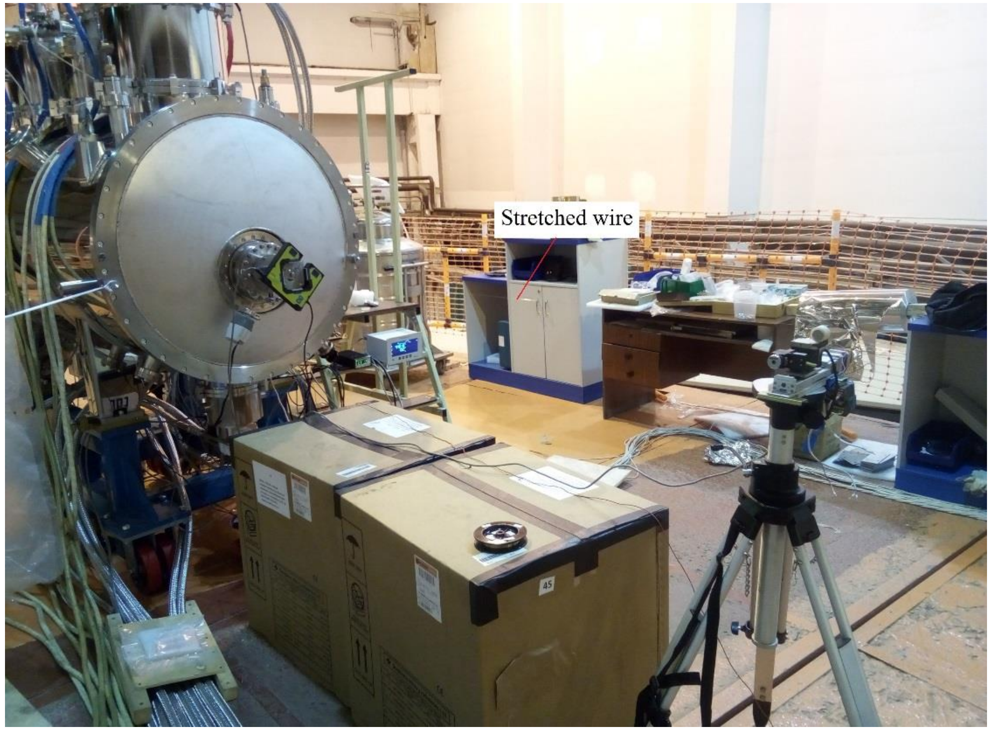
Such difference makes more critical heating of 20 K vacuum chamber in indirect cooling wiggler then heating of 20 K liner in direct cooling wiggler. In first case irradiation from vacuum chamber heats the coils in vacuum and may provoke quench. In second case the irradiation from 20 K liner heats helium temperature vacuum chamber and may cause helium consumption. But while there is helium inside helium vessel the coils have liquid helium temperature and can work without quench.

In both case for magnetic measurements we need to use antichamber (for carriage with Hall probe or for stretched wire). But in case of indirect cooling wiggler we need to take more care to avoid thermal conductivity between antichamber and 20 K vacuum chamber.
For wigglers we talk about we used rectangular antichamber which also was a rail for carriage with Hall probe. The space between antichamber and vacuum chamber was pumped out. At the one side of the wiggler antichamber had fixed mount to wiggler flange. At the other side the antichamber had a possibility to slide with respect to wiggler flange. Such design is necessary because of vacuum chamber became shorter in process of cooling down while the antichamber has room temperature and does not change its length. The difference in length reached 7 mm.
One of the problem connected with small vertical aperture was impossibility to make enough thick antichamber wall. So it was enough difficult to make hermetically connection of antichamber with wiggler flange at the sliding end. This connection is Wilson seal with rubber gasket. So it was very small range between permissible weak and strong tightening.



The carriage with Hall probe.

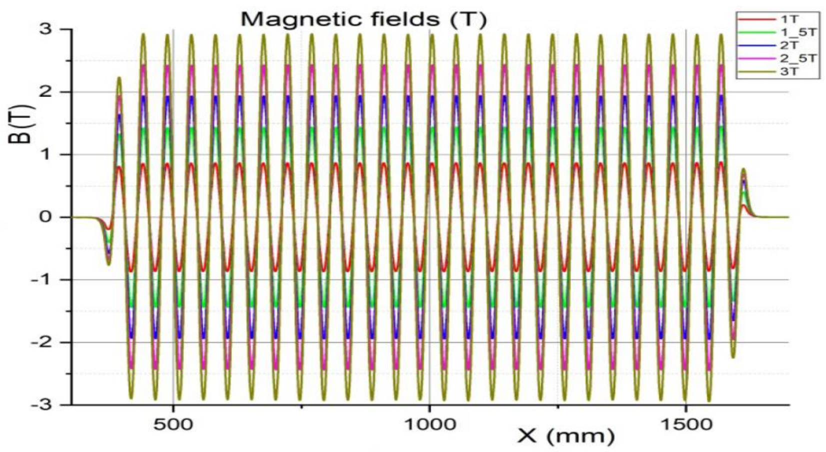
Its rectangular cross section is the same as the antichamber inner cross section.



Stretched wire for integral measurements.

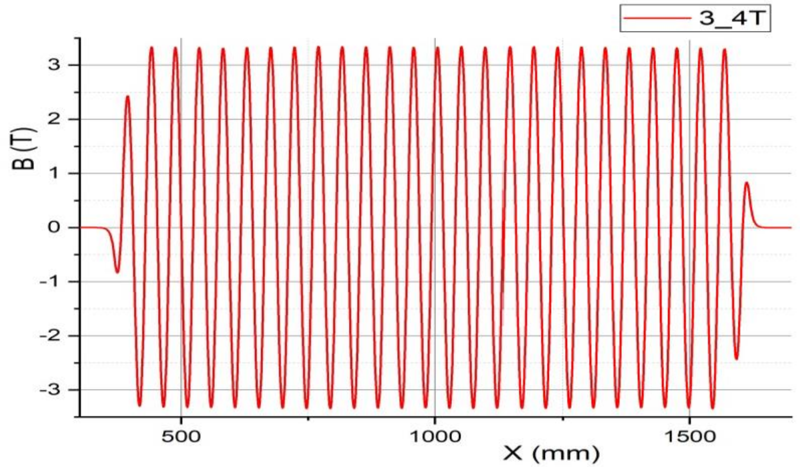
You can see also wire position sensor near wiggler flange at this picture.

Some of measurements results.

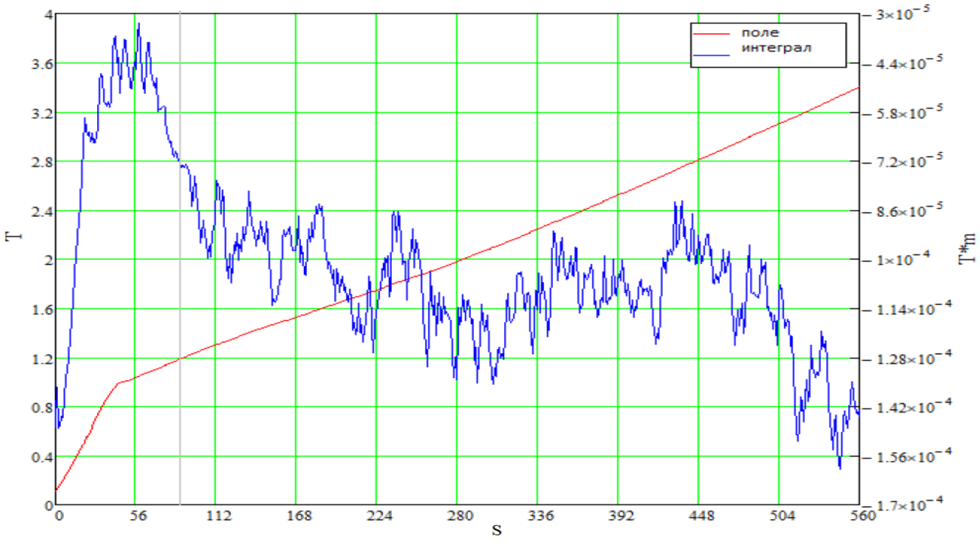


Longitudinal magnetic field distribution for different peak field level.

Hall probe measurements.

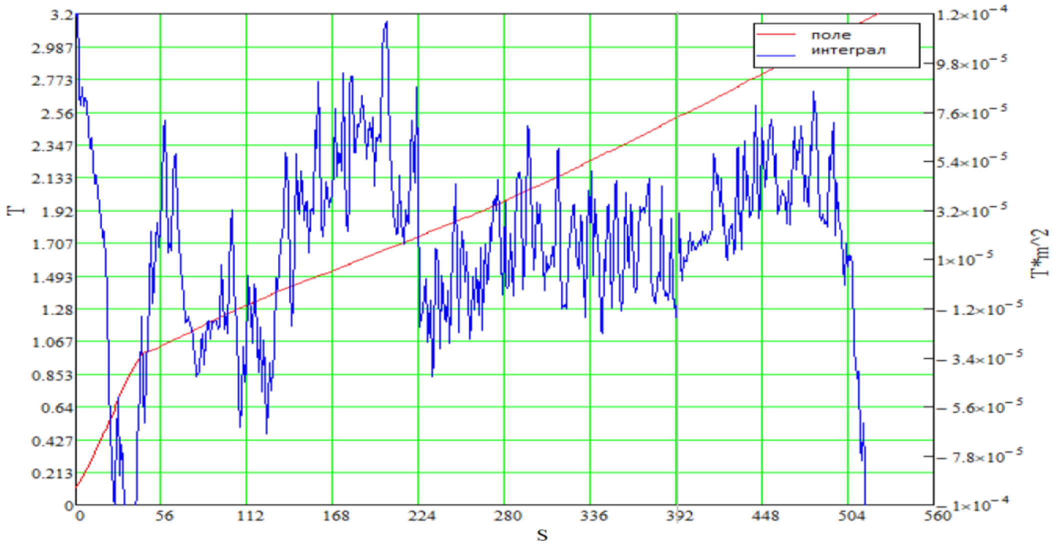


Longitudinal magnetic field distribution for 3.4 Tesla peak field.



Peak magnetic field and first field integral in process of field ramping up.

Measurements of first and second field integrals by stretched wire method.



Peak magnetic field and second field integral in process of field ramping up.