INDIRECT COOLED SUPERCONDUCTIVE WIGGLER MAGNET

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Abstract

Superconducting wigglers are very popular devices for generation of the synchrotron radiation in the hard X-ray spectral range. The one direction of the future progress in wigglers development is reducing of the technical complexity wigglers design as well as technical service for cryogenic system. The BINP wigglers without liquid helium consumption were a noticeable milestone of these efforts. The next significant step toward additional simplification wiggler design and service is indirect cooling of the wiggler magnet. In this case the wiggler magnet not immersed into the liquid helium, but cooled by thermal connection link with the head of cryogenic cooler.

This approach is used for design of the indirect cooled wiggler for IMAGE beamline on the ANKA light source (KIT, Germany). This wiggler also will be tested as a prototype for damping wiggler for the damping rings in the project of the Compact Linear Collider (CLIC) for CERN.

This report summarizes some details of the wiggler design as well as a result of the short prototype testing.

INTRODUCTION

Budker Institute of Nuclear Physics produced more than twenty superconductive insertion devices which are working now in many SR centres over whole world [1-5].

During thirty years history the number of goals for design has been established and fulfilled. Among different goals, the simplicity of the regular service and cryogenic requirement is a very important.

From this point of view the wigglers development history can be divided by few period. The fist devises used a external storage for liquid helium, and operation procedure included regular refilling, Later the using of the commercial available Gifford-McMahon cryocoolers permits reduced difficulties of regular cryogenic operations, essentially reduce LHe consumptions and increase the refilling time.

Cryocoolers and common progress in the cryostat design permits achieve the real zero consumption of the liquid helium, and since 2005 all manufactured devises have this feature.

A currently developed wiggler can be the next step in the cryogenic design. Here magnetic coils connected with LHe volume by the number of cupper links and thermosiphons. This approach permits to have relatively simple access to the magnet and to the beam vacuum chamber. Principally it's possible to change whole magnetic system inside cryostat during relatively short time period (about two weeks) without complicated operation (machining, welding).

This approach had been selected for prototype of the damping wiggler for CLIC damping ring [6]. The huge number of wiggler on the damping ring requires extremely high reliability for every wiggler, so traditional approach for magnet isolation in the LHe tank is not suitable for this task. Moreover final selection of the CLIC damping wiggler design requires testing different technologies for coils wiring and the beam vacuum chamber coatings. It is possible test different options inside single cryostat.

The currently developed wiggler is dedicated for such research work as well as for regular work for SR user on the IMAGE beam line at ANKA storage ring. In according to agreement between CERN, KIT and Budker INP this wiggler should be installed on the ring in the middle of the 2013.

PARAMETERS OF THE WIGGLER

The main parameters of the wiggler are presented in the Table 1. These parameters are the subject of the compromise between CERN and KIT requirement.

Table 1: Main parameters of the wiggler with indirect cooling

Parameter	Value
Period	51 mm
Peak fiels	3 T
Magnet structure	1/4,-3/4,1,-1,…,-1,3/4,-1/4
Number of the full field poles	68×2
Full number of the poles	72×2
Magnetic gap	18 mm
Vacuum chamber vertical aperture	13 mm
Beam heat load	50 W
Maximum ramping time	< 5 min
Period for LHe refill with beam	> 6 months
LHe boil off @ quench	< 15
Field stability for two weeks	$\pm 10^{-4}$

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WIGGLER DESIGN

Magnetic Poles

Magnetic pole is a basic element of the wiggler magnetic system. The design of the pole should satisfy the magnetic field requirements, in other hand should provide the reliable cooling of the superconductive coils.

In current project the ARMCO iron pole kernel has a special shape with big parallelepiped in rear side (Figure 1). This part work like a yoke for closing magnetic flux between neighbour poles, and permits make reliable big cross-section connection with cooling links.

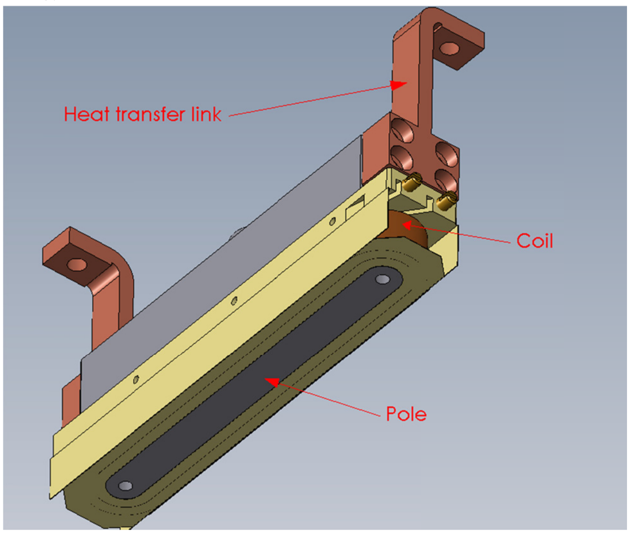

Figure 1. The general view of the wiggler pole

This design of the pole provides effective cooling of the most critical internal layer of the superconductive coil. As in most BINP wigglers each main pole has a two nested coils. This solution more effective satisfies for critical conditions for high currents and magnetic fields values. Coils are wound by 500 A NiTi superconductive wire with 0.9 mm diameter.

Magnetic System

Figure 2 shows the general layout of the magnetic assembling. Assembling consist from two independent halves for providing easy access to vacuum chamber.. Poles are fixed in the yoke frame. On the rear pat of yoke the special cupper plate with LHe channel is located. The cooling links of all poles thermally connected with this plate. Vacuum chamber is connected with 20 K stages of cryocoolers. These links cross-section is selected to evacuate 50 W SR load from internal surface of vacuum chamber. This load is possible in the case of multiply wiggler section of the CLIC damping ring by radiation of the upper flow wigglers.

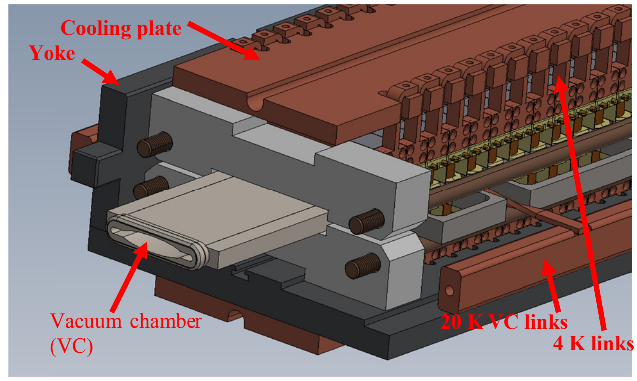

Figure 2. Magnetic system assembling.

Cooling Conception

Figure 3 presents the cooling scheme of the wiggler magnet. Wiggler cold mass includes LHe volume (about 90 l) which connected with magnet by two thermo-siphon pipes.

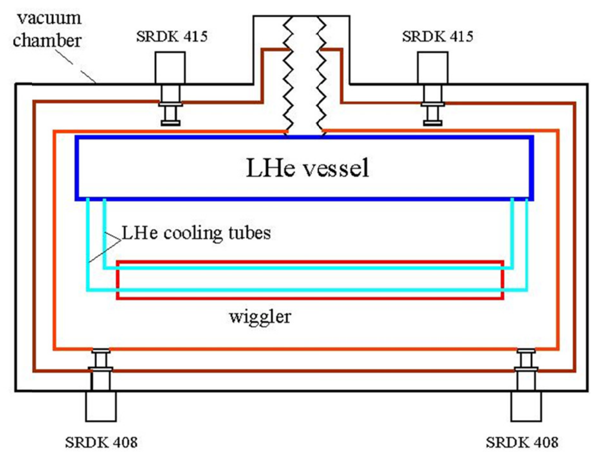

Figure 3. The scheme of the wiggler cooling conceptions

Cold mass is suspended in an isolation vacuum and surrounded two thermal shields with temperatures 20 K and 70 K. Cold mass is connected with 4 K stages of the two SHI SRDK 415 cryocoolers which permit evacuate about 2 W power.

Another two SRDK 408 cryocoolers are connected with thermal shield and vacuum chamber.

Figure 4 show the cross-section of the wiggler in detail.

Other Components

Principally with exception of the cold mass, the designs of other wiggler components are similar to convential BINP wigglers. This set includes current lead system, thermal shields, superisolation mates, Kevlar ropes suspension system, RF shield and temperature transition for vacuum chamber. The designs of these components were optimize during long history of the BINP activity in the developing and fabrication of the superconductive wigglers [1-5].

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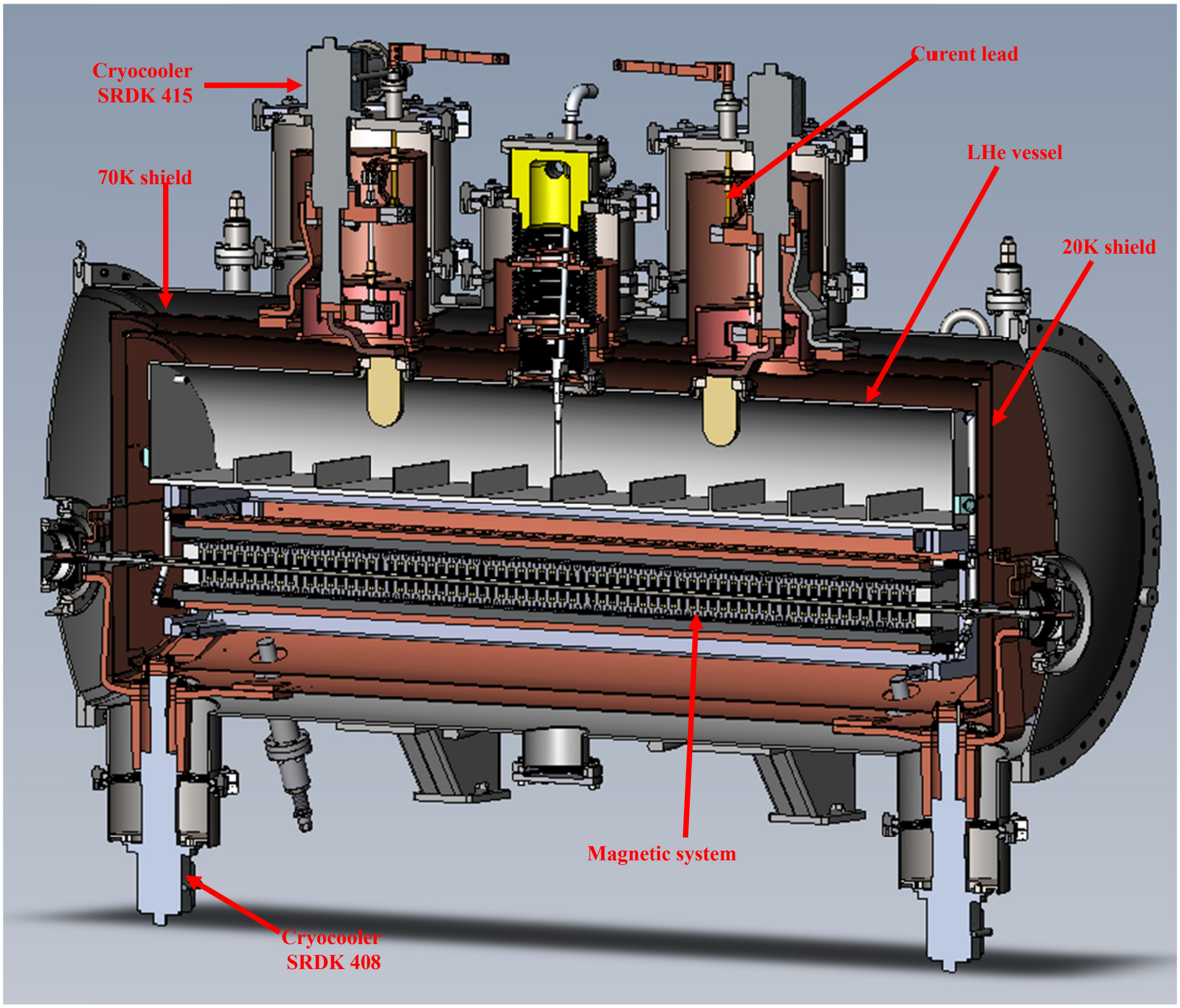

Figure 4: The cross-section of the assembled wiggler..

PROJECT SCHEDULE

In according with current contract between KIT, CERN and Budker INP the next schedule for main milestones had been established:

• Conceptual design report	May, 2012
• Short prototype testing	Oct., 2012
• Full design report	Oct., 2012
• Fabricating	June, 2013
• Factory acceptance tests	Aug., 2013
• Site acceptance test, commissioning	Sept., 2013

REFERENCES

[1] Kulipanov G.N., Mezentsev et al., Development of superconducting compact storage ring for technical purposes in the USSR. Rev. Sci. Instrum. 63(1), 1992, p.731-736.

[2] Mezentsev N.A, Shkaruba V.A., et al., Superconducting 7.5 Tesla wiggler for PLS. NIM, Vol. A359, No.1-2 (1995),p.101-106.

[3] Kulipanov G., Li O., Mezentsev N., et al., Superconducting 7 Tesla wiggler for LSU CAMD. Journal of Synchrotron Radiation (1998), Vol.5, Part 3, p.440-442.

[4] A. Batrakov, V. et al., Magnetic measurements of the 10T Superconducting Wiggler for the SPring-8 storage ring. Proc.of 7th International conference of Synchrotron Radiation Instrumentation, Berlin, 2000.

[5] S.V. Khrushchev, V.K. Lev, N.A. Mezentsev, E.G. Miginsky, V.A. Shkaruba, V.M. Syrovatin, V.M. Tsukanov, A.A. Volkov, J. Campmany, D. Einfeld Superconducting 119-pole wiggler for ALBA light source. Proc. of IPAC-2011, San Sebastian, Spain.

[6] H. Schmickler et al., "Technology Developments for CLIC", MOYCH03, these proceedings.

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