MAGNETIC MEASUREMENTS OF THE 63-POLE 2 TESLA SUPERCONDUCTING WIGGLER FOR CANADIAN LIGHT SOURCE

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The magnet measurement methods for a multipole superconducting wiggler using the Hall probes and stretched wire are described. The results of magnet measurements for the 63-pole superconducting wiggler are presented. The measurements have been carried out in the bath cryostat (with the Hall probes temperature 4.2 K) as well as in its own cryostat using a special scanning room temperature antechamber.

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1. INTRODUCTION

The superconducting wiggler under discussion was designed and fabricated in accordance with the contract between Budker INP and Canadian Light Source, Saskatchewan, Canada. The superconducting wiggler is an array of alternating sign dipole magnets immersed into liquid helium. The vacuum chamber is a part of a liquid helium vessel and is inserted into a pole gap. A copper liner with a temperature 20 K is inserted inside the vacuum chamber to prevent heating of the liquid helium vessel excited by an electron beam. Space available for the electron beam is defined by the copper liner and equal to 50×9.5 mm.

The wiggler magnet system should satisfy the contract requirements for field quality to predict an influence of the wiggler field on a beam dynamics. The similar work was done by Budker INP for other superconducting insertion devices for various SR centers [1,2]. In order to check the field quality during the wiggler fabrication and after wiggler assembling inside its own cryostat, magnetic field measuring systems were used. The main problems during the magnetic measurements are a low temperature (4.2 K and 20 K) and a very small space for the magnetic field probes. The magnet and cryogenic design of the wiggler are presented in [3].

2. MAGNETIC MEASUREMENTS IN THE BATH CRYOSTAT

After the fabrication and assembling of the wiggler magnetic system, it was tested in the bath cryostat. The magnetic measurements have been carried out by using an array of five LakeShore Hall probes which were placed inside the liquid helium at 4.2 K. The Hall probes were mounted on a rotating disk with a rotation angle of 90 degrees. In spite of that the Hall probes were previously calibrated at 4.2 K and high level field value, there is no guarantee that calibration will be the same after subsequent cooling down. In order to increase the field quality measurements, a relative calibration procedure was performed first. For the calibration procedure, the Hall probes array was rotated in such a way that the probes are going in one way following one another for the relative probes calibration. The next measurements have been carried out when the probes are placed perpendicular to the motion direction. In this case, during the probes movement, the magnetic map in one plane has been measured.

3. MAGNETIC MEASUREMENTS IN THE OWN CRYOSTAT

The magnetic measurements of the wiggler assembled within its own cryostat have been done with the use of a special scanning measuring system. The assembled wiggler length from flange to flange is about 2.2 meters. As was mentioned above, the accessible space for the magnetic measurements is 9.5×50 mm and is defined by the copper liner (at the temperature about 20 K).

Thus, to make the magnetic measurement conducting at a room temperature, an antechamber has been used inside the copper liner. This is a titanium tube with an internal diameter of 6 mm (see Fig.1). This tube is movable and is a part of the scanning system. There are two types of the measurements that can be done with this tube – the magnetic map measurements with the use of the Hall probe inside the tube and the field integrals measurements with a wire with a current placed inside the tube. The scanning range of the tube is ±15 mm in the horizontal plane and ±1 mm in the vertical plane (at the central horizontal position only). The photo of the one part of the system is presented in Fig.2.

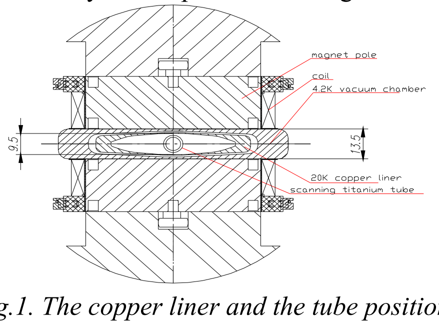


Fig.1. The copper liner and the tube positions

All control and measuring equipment is produced according to the VME standard.

3.1. WIGGLER MAGNETIC MAP MEASURING

Due to a small internal size of the tube only two Hall probes are used for the magnetic map measurements. These two probes were mounted perpendicular one another to measure simultaneously the vertical B_y and horizontal B_x magnetic field components. 3-D magnetic field map is a result of scanning of tube ends in X and Y directions and the Hall probes movement inside the tube with appropriate steps.

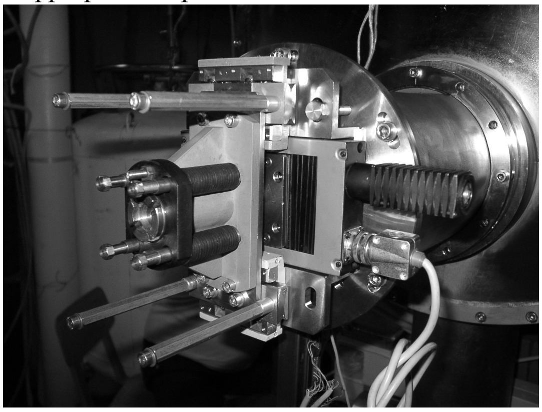


Fig.2. Photo of the scanning part of the system

Simultaneous measurements of the magnetic field components B_x and B_y give a possibility to make correction to the magnetic field strength in the median plane in case of the Hall probes rotation as whole during longitudinal scanning. The minimum step between the measurements along the wiggler is 0.1 mm.

Fig.4,a and Fig.4,b show B_x and B_y field components behavior along the wiggler at 2 T magnetic field. The angle and the full magnetic field value taking into account both the field components are presented in Fig.4,c and Fig.4,d, correspondingly. An overlapping of 5 longitudinal passes of the Hall probe with the horizontal coordinate at -10 mm, -5 mm, 0 mm, 5 mm, 10 mm at the field of 2 Tesla are presented in Fig.3.

3.2. FIELD INTEGRALS MEASUREMENTS

A stretched wire method was used for the magnetic field integrals measurements. This method has been already applied for previous wigglers measurements [4].

In the proposed wiggler field integrals measurements, the Hall probes were replaced by a wire with a current. The DC current of the wire is 2 A. The wire was stretched with force of 19N for modeling of 2.9 GeV electron beam. The AC current with 1.125 MHz are used for wire position monitoring during the measurements. The measurement precision of the ± 1 mkm corresponds to the 2 Gs*cm of the first field integral and 500 Gs*cm^2 for the second field integral.

The scheme of the wire method is presented in Fig.5.

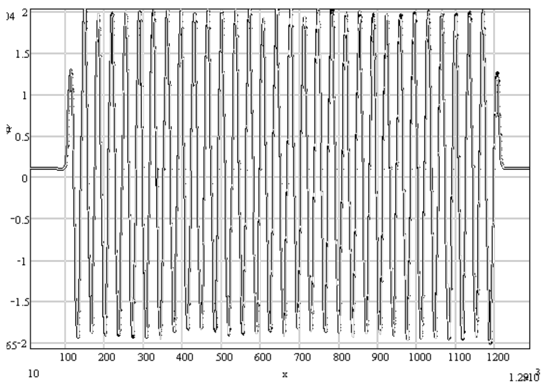
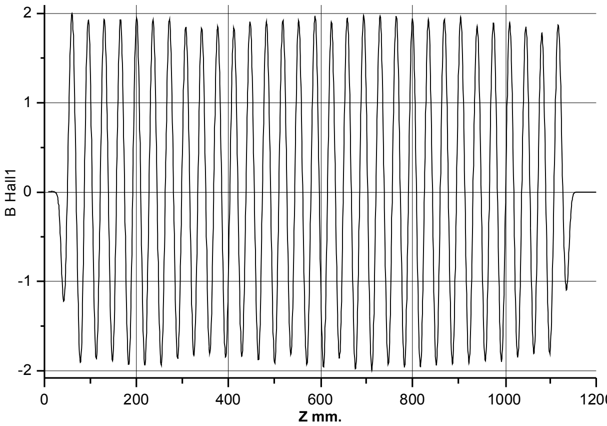
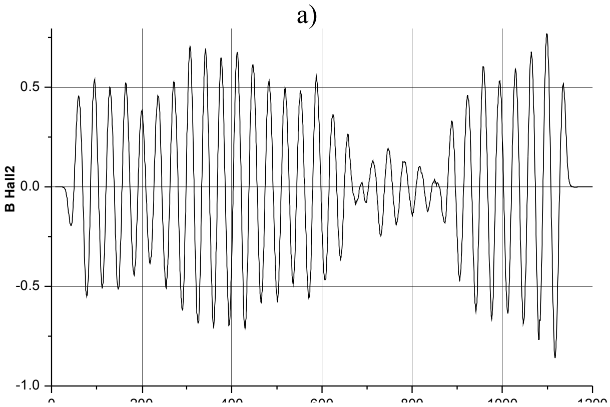


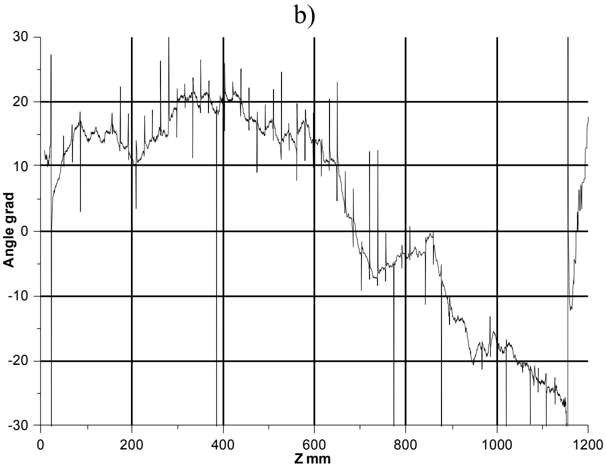
Fig.3. Overlapping of 5 longitudinal passes of the Hall probe with the horizontal coordinate of -10 mm, -5 mm, 0 mm, 5 mm, 10 mm at the field of 2 Tesla



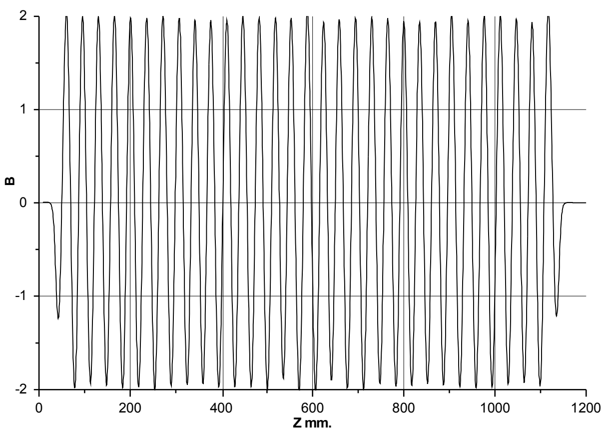
a)



b)



c)



d)

Fig.4. Results of the magnetic field measurements at 2 Tesla magnetic field: (a)B_z field component,

(b) B_y field component, (c) rotating angle of the Hall probes (degree), (d)full magnetic field

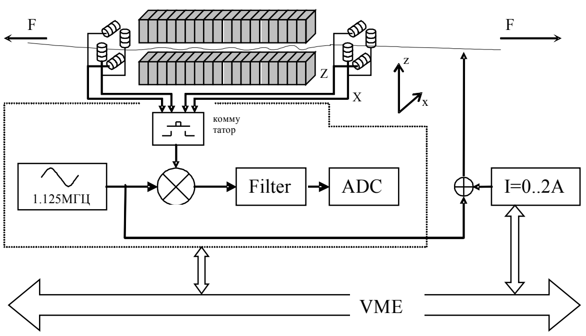


Fig.5. The scheme of the stretched wire method

A dynamical stability of the first and second integral during ramping up and down of the wiggler field with the help of the stretched wire method was tested. The results are shown in Fig.6 and Fig.7.

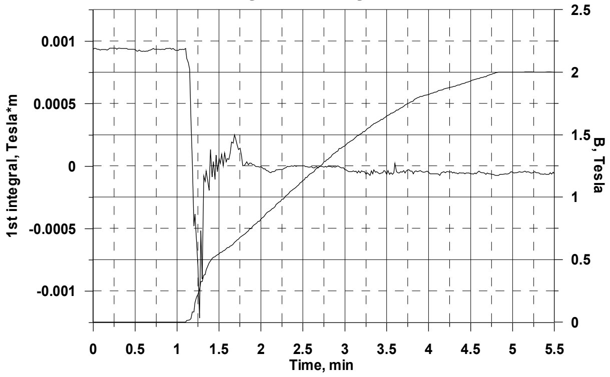


Fig.6. First field integral behavior during ramping up of the wiggler field

RESUME

The magnetic field measurements of the superconducting multipole wiggler were carried out under conditions of the very low temperature and small available space. The results are in good agreement with the calculations and the contract requirements.

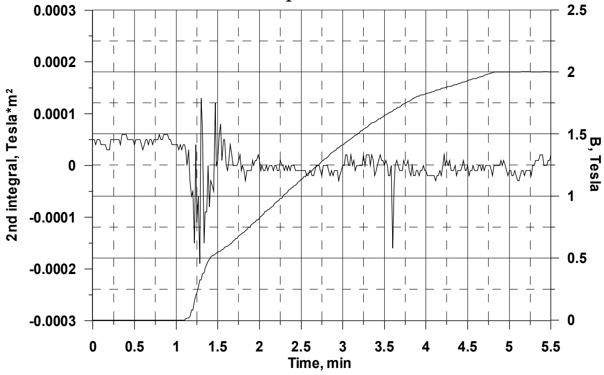


Fig.7. Second field integral behavior during ramping up of the wiggler field

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МАГНИТНЫЕ ИЗМЕРЕНИЯ 63-ПОЛЮСНОГО СВЕРХПРОВОДЯЩЕГО ВИГГЛЕРА С ПОЛЕМ 2 ТЕСЛА ДЛЯ КАНАДСКОГО ИСТОЧНИКА СИНХРОТРОННОГО ИЗЛУЧЕНИЯ

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Описаны методы магнитных измерений для многополюсного сверхпроводящего вигглера с использованием датчиков Холла и натянутой проволоки с током. Приведены результаты магнитных измерений 63-полюсного сверхпроводящего вигглера в погруженном (при температуре датчиков Холла 4.2 К) и собственном (с использованием специальной сканирующей аванкамеры комнатной температуры) криостатах.

МАГНІТНІ ВИМІРИ 63-ПОЛЮСНОГО НАДПРОВІДНОГО ВІГГЛЕРА З ПОЛЕМ 2 ТЕСЛА ДЛЯ КАНАДСЬКОГО ДЖЕРЕЛА СИНХРОТРОННОГО ВИПРОМІНЮВАННЯ

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Описано методи магнітних вимірів для багатополюсного надпровідного вігглера з використанням датчиків Холу й натягнутого дроту зі струмом. Наведено результати магнітних вимірів 63-полюсного надпровідного вігглера в зануреному (при температурі датчиків Холу 4.2 К) і особистому (з використанням спеціальної скануючьої аванкамери кімнатної температури) кріостатах.