



TITLE:

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Development of a field measurement system for the Bulk HTSC SAU

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Abstract. To realize a short-period strong-field undulator, we proposed a high temperature superconducting bulk staggered array undulator (Bulk HTSC SAU) and proceeded proof of principle experiments and numerical studies. We have succeeded to generate periodic transverse magnetic fields whose strength was controlled by an external solenoid field. At the same time, we revealed a problem; at both ends of undulator, field distribution is substantially distorted. We proposed several approaches of field correction. To verify the effectiveness of these field correction methods, it is necessary to measure the magnetic field distribution precisely, not only inside of the undulator but also both ends. For this purpose, we developed a rotary measurement system to measure the magnetic field distribution at the end of the undulator. Multiple Hall sensors are placed on a circuit board at equal intervals from the centre of the board. By rotating and moving the board, the probe can measure axial field in 3D space on the undulator ends. In this paper, we deliver specifics of the system.

1. Introduction

Short period and high magnetic field undulator contributes to develop light sources like FEL. To realize this, we have proposed a high temperature superconducting bulk staggered array undulator (Bulk HTSC SAU) shown in figure 1. Proposed Bulk HTSC SAU is magnetized by an external solenoid below 77 K, the gap of undulator is 4.00 mm and the diameter of bulk is 28.2 mm. We studied proof of principle experiments with a prototype undulator. However, there are strong magnetic field peaks on the both edges of Bulk HTSC SAU (figure 2) [1, 2] Critical temperature of Bulk HTS is 91 K [3]. Considering applying the undulator for light sources, these strong magnetic fields on both ends will kick electron beam. These strong fields may occur due to non-uniform magnetization or variability of critical current density of bulk HTS [4]. However, no report is available on undulator field on both ends made by bulk superconducting magnet. Regarding this point, we should measure spacious magnetic distribution on both ends of undulator.

Existing measurement system needs a large vacuum chamber due to envelop linear guides [5], so it cannot apply for Bulk HTSC SAU. Since Bulk HTSC SAU is stacked in cooling duct, magnetic field should be measured in a limited movement, and, moreover, should be measured not only inside of undulator, but also both ends. Regarding these conditions, we propose a new 3D magnetic field measurement system in a compact design.

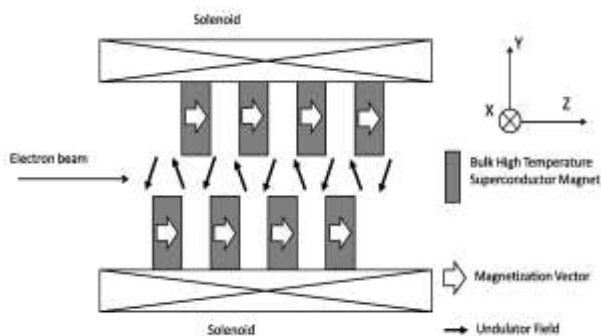


Figure 1 Conceptual diagram of Bulk HTSC SAU

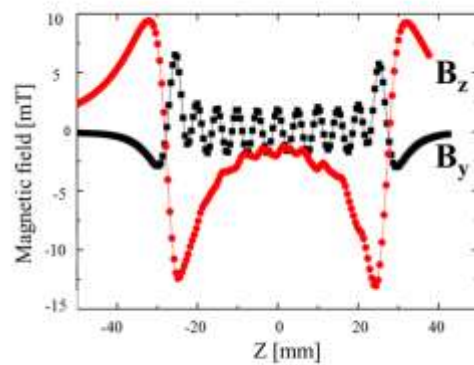


Figure 2 Magnetic field of Bulk HTSC SAU (DyBaCuO, @ 77 K)

2. Design

The measurement system is constructed with a solenoid, probe with hall sensors, and a refrigeration system. The instrument has following two features: first it can measure magnetic field of beam direction (B_z) under in-vacuum and low temperature condition, in other words, it can measure in-situ beam direction field unlike usual instruments for measuring undulator field, and second it can measure in-situ surface magnetic field (B_y) of a bulk on the edges of undulator.

2.1. External solenoid

The custom solenoid, manufactured by CRYOMAGNETICS, INCORPORATED, whose diameter of bore is 76.2 mm and whose super conducting magnet is Twisted Multi-filamentary NbTi/Cu, generates 2 T at 4.2 K. Bulk magnets stacked in holder are inserted on the left window in figure 3 and a probe in holder are inserted on the right window in figure 3. These sample and probe are cooled through contact with a duct by cryostat.

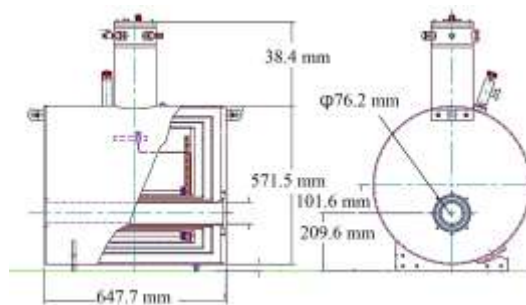


Figure 3 Solenoid for Bulk HTSC SAU

2.2. Probe

The probe shown in figure 4 is constructed with a top part and a bottom part, the former has a thermometer (Lake Shore Cryotronics, Inc, CX-1050-CU-HT-1.4L) and five custom-made hall sensors (Arepoc HHP-NU) whose active range is 0.01 mm^2 for measuring field of beam direction, and the latter has five hall sensors for measuring field of transverse field. The distance of these two parts is 3.65 mm and the diameter of them is 28.5 mm. Rotation and linear translation (z in figure 4) of the probe easily enables us to measure the 3 dimensional distribution of B_z and B_r field.

The driving system of the probe is as follows. MDC Vacuum Products, LLC RMTG-275-01 is used for revolving motion (motor : LIN ENGINEERING 5718L-01), MDC Vacuum Products, LLC BLM-275-6-03 SPEC D is used for linear motion (motor : slo-syn M061-

CE02). Driver for these motor is NIDEC SERVO CORPORATION FSD2U2P14-01 and controller for these is Interface PCI-7414M. Figure 5 shows driving devices.

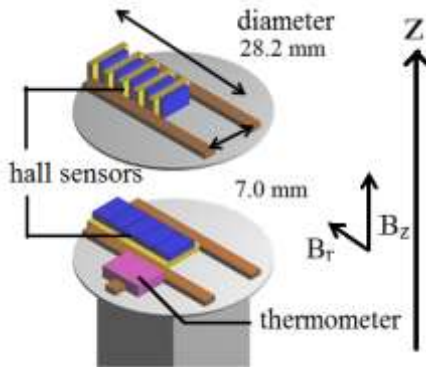


Figure 4 Rotary probe

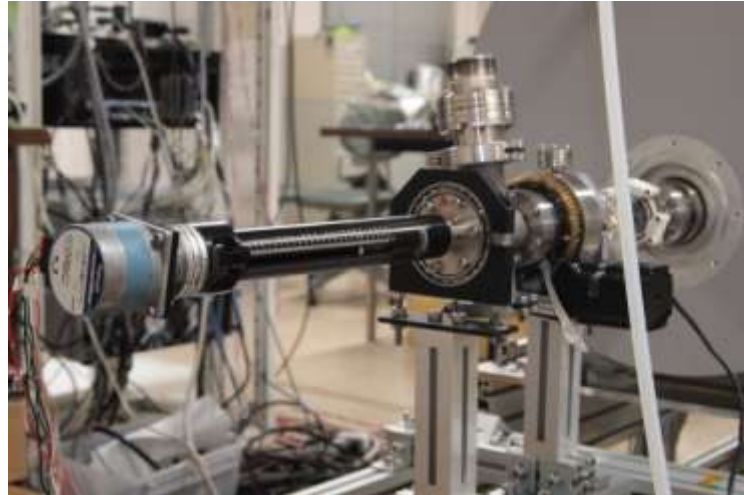


Figure 5 Driving devices

2.3. Refrigeration system

Figure 6 shows refrigeration system. Custom designed continuous flow cryostat, CRYO INDUSTRIES, CFM-2736-102, based on RC102 series, is used to cool a sample. Bulk HTSs attached to the sample holder are indirectly cooled by inner duct which is cooled with He. Temperature of the bulk HTSs can be monitored using cernox thermometer. Minimum temperature at the sample is 6 K and can be controlled using a heater.

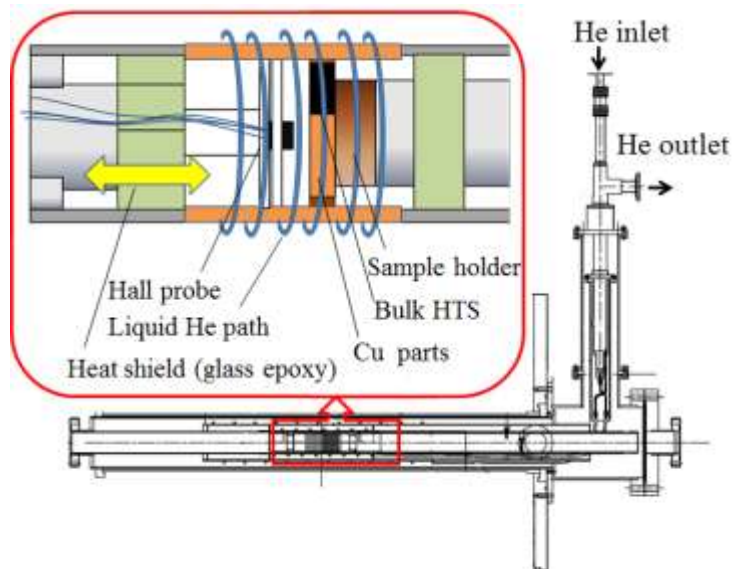


Figure 6 Refrigeration system

3. Summary

To realize a short period and high magnetic field undulator by Bulk HTSC SAU, we designed a field measurement system; a probe holder, a motion system, a refrigeration system. As a next step, we plan to demonstrate the system and assess the accuracy by comparing conventional 2D scan measurement system at room temperature. Finally, we will measure precisely magnetic field distribution at both ends of bulk HTSC SAU to verify the effectiveness of our field correction methods.

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