Advanced Research Center for Beam Science
– Particle Beam Science –

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Scope of Research

Particle accelerators have been contributing on progress of science in a variety of fields. Among these fields, our current activity covers neutron science and participation in International Linear Collider (ILC) project. Including subsidiary subjects, the following subjects are being studied: neutron beam focusing by modulating sextupole magnets, neutron acceleration/deceleration, compact neutron source including ion source, permanent quadrupole magnets for final focusing of ILC, nondestructive inspections for superconducting accelerating tube towards higher yield and performance and multi layered film structure for RF.

KEYWORDS

Beam Physics
Accelerator Physics
Neutron Optics
Phase Rotation
International Linear Collider

Selected Publications

Arimoto, Y.; Geltenbort, P.; Imajo, S.; Iwashita, Y.; Kitaguchi, M.; Seki, Y.; Shimizu, H. M.; Yoshioka, T., Demonstration of Focusing by a Neutron Accelerator, *Phys. Rev. A*, **86,** 023843 (2012).

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Arimoto, Y.; Yoshioka, T.; Shimizu, H. M.; Mishima, K.; Ino, T.; Taketani, K.; Muto, S.; Kitaguchi, M.; Imajo, S.; Iwashita, Y.; Yamashita, S.; Kamiya, Y.; Yoshimi, A.; Asahi, K.; Shima, T.; Sakai, K., Longitudinal-gradient Magnet for Time Focusing of Ultra-cold Neutrons, *Physics Procedia*, **17,** 20-29 (2011).

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Iwashita, Y.; Tajima, Y.; Hayano, H., Development of High Resolution Camera for Observations of Superconducting Cavities, *Phys. Rev. S.T.-Accel. Beams*, **11,** [093501-1]-[093501-6] (2008).

Non-destructive Inspection for the Superconducting Cavity by XT-map System

The upper limit of the accelerating gradient of the superconducting (SC) cavity for the particle accelerator seems to be affected by the condition of the interior surface. Main causes of limiting accelerating gradient are thought to be the quench from local heat source and field emission due to defects such as scratches, dust particles in tens of μm and ruggedness of a few hundreds μm. In order to improve the performance and the production yield of the SC cavities, non-destructive inspections for finding defects on the interior surface of SC cavity have important roles.

About 15000 SC cavities with the average accelerating gradient of 32MV/m are required for the first stage plan of the International Linear collider (ILC). Because of the number of such many SC cavities to be produced, several research laboratories have made R&D of various inspection methods. As a method for survey and observation of defects on the interior surface, the high-resolution camera system, so-called Kyoto Camera, was developed. Kyoto Camera used in several research laboratories is an effective non-destructive inspection tool at the room temperature environment. On the other hand, the multi-point thermometry mapping measurements (T-map) and the multi-point X-ray radiation mapping measurements (X-map) are useful tools to survey the defect locations during the vertical test. The vertical test is the performance test of SC cavity by feeding RF power to cavities at cryogenic temperature environment (liq. He). T-map, X-map and the optical observation are complementary to each other for the purpose. Those inspections are recognized as essential processes for the local repairing of the interior surface together with the micro grinder after identified the defect locations.

Our XT-map system under development in collaboration between Kyoto University and KEK is a combined system of T-map and X-map. The ruthenium oxide chip resistors with good availability and a low cost are adopted as the temperature sensors of XT-map in instead of the expensive commercial cryogenic temperature sensor or the carbon resistors. Whole T-map assemblies for 9-cell cavity will contain about 9000 (X-map: 4500) sensors. The high-density sensor distribution of the XT-map gives the high resolution. Many cabling wires for this multi-point measurement would increase the heat intrusion into the cryostat. In order to reduce the number of the signal cables significantly, CMOS analogue multiplexers have been installed in the cryogenic area. And the daisy-chained FPC boards pass a token sequentially during data scan of all analog data on each board. Because the huge amount of sensor lines are multiplexed at a hi-speed scanning rate in the vicinity of the sensors, the small number of signal lines makes the installation process easy and reduces the system complexity.

A preliminary quench detection test of XT-map was performed on a SC cavity which was known to have a quench location by a previous vertical test at KEK. As shown in Figure 3, XT-map FPC boards were installed on 1/4 area of a cell, and we succeeded in the detection of a heat generation as shown in Figure 4.

Basic design of XT-map system for non-destructive inspection during the vertical test has been established. Although sensitivity of the adopted X-map and T-map sensors are less than those used in other laboratories, both sensors show sufficient performance in our XT-map system. Issues such as insufficient thermal contact of sensors with the cavity surface found in this quench detection test will be resolved in a next version.

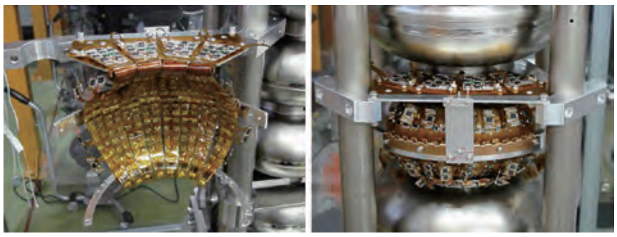

Figure 3. Installation of test of XT-map assemblies for the quench detection at KEK.

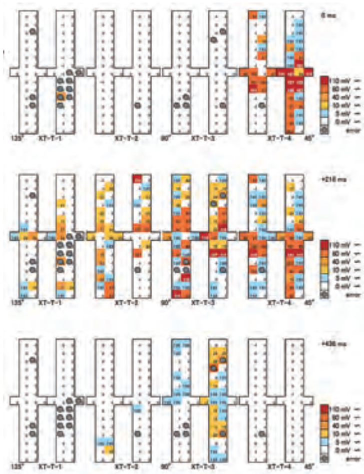

Figure 4. A typical measurement result of the quench detection test of XT-map during the vertical test. The circles are quench location previously observed by KEK T-map. The output value of 100 mV corresponds to a temperature rise from 2K to 10K.

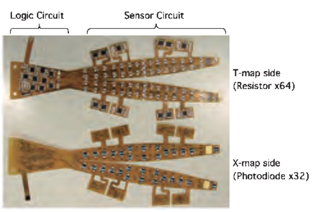

Figure 1. The double-leaf-shaped Flexible Printed Circuits films (polyimide film with several layers) for XT-map.

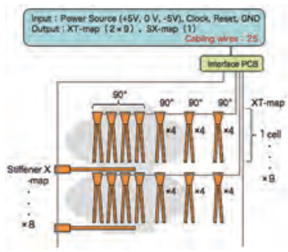

Figure 2. The schematic drawing of our inspection System (XT-map and Stiffener X-map system).