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PRELIMINARY DESIGN OF SUPERCONDUCTING CAVITY TEST PLATFORM IN CSNS CAMPUS*

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Abstract

For the beam power upgrade of CSNS (China Spallation Neutron Source) and the construction of the high performance photon source in South China in the near future, the superconducting cavity test platform which includes vertical test stand, single cavity horizontal test stand, cryomodule horizontal test stand and coupler test stand will be built. This paper will generally introduce the preliminary design of the test platform and corresponding test parameters.

INTRODUCTION

CSNS was completed and put into official operation on August 23, 2018. Currently, room temperature RF (radio frequency) cavities are used in the accelerating system. The superconducting cavity will be adopted for the CSNS power upgrade and the future high performance photon source in South China due to its multiple advantages. The Linac beam energy will be upgraded from 80 MeV to 300 MeV in CSNS-Ⅱ. And the selectable cavity types for the upgrade of CSNS contain 324 MHz spoke cavity and 648 MHz 5 cell ellipsoidal cavity. The reserved length for superconductor cavity is about 85 meters. The system function structure of CSNS superconducting cavity test platform is shown in Fig. 1.

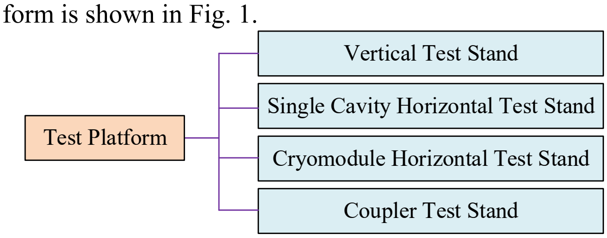

Figure 1: System function diagram.

TEST STANDS

This report introduces the preliminary design of the test platform which contains vertical test system, horizontal test system and coupler test system. Superconducting RF cavity test systems generally include cavities, magnetic shields, tuners, main couplers and low level controls, etc. The main test parameters include accelerating gradient E_{acc}, the quality factor Q, the surface resistance R_s, etc.

Vertical Test Stand

The vertical test is an evaluation of the RF performance at 2K or 4K temperature, after the superconducting cavity is processed and post-processed. The shortcomings are found and direction is provided for improvement. It is an important part of the development process of the superconducting cavity. Only the superconducting cavity which meets the standard of performance through vertical test can carry out the overall assembly work. In the vertical test, the superconducting cavity is suspended on the hanger, lowered into the dewar and immersed in liquid helium. The accelerating gradient E_{acc} and quality factor Q of the cavity are tested under this condition [1]. The vertical test is the most direct and easiest way to test the performance of the superconducting cavity. It is the preferred test method for the experimental cavity, and it is also the routine practice to judge whether the cavity performance is up to standard when the superconducting cavity is mass-produced. According to the principle of low temperature engineering, the VT (vertical test) dewar adopts a three-layer structure, the outermost layer is a normal temperature stainless steel outer cylinder, the middle layer is an 80 K copper cold screen and the inner layer is a liquid helium cylinder whose inside is filled with liquid [2]. In addition, the inner and outer magnetic shields are used to shield the earth's magnetic field ensuring the magnetic field in the hoisting area of superconducting cavity in the dewar low enough to meet the test conditions of the superconducting cavity. The dewar schematic and dimensions are shown in Fig. 2.

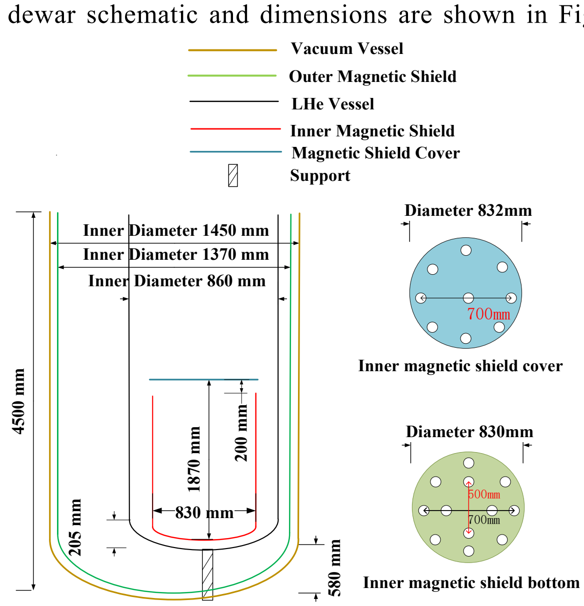

Figure 2: Vertical test dewar diagram.

By referring to the design scheme of Fermilab [3], the vertical test pit design scheme is shown in Fig. 3. The radiation dose probes are placed at the bottom of the test pit, at the top of the test pit, and at the top of the test dewar. The

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dose monitor is in the VT control room. During the test, when the dose at the bottom of the test pit is greater than 10 mSv/h or the dose in the control chamber is higher than the background, the low-level control system will issue an interlock signal to cut off the incident signal of the amplifier to ensure the safety of the equipment system.

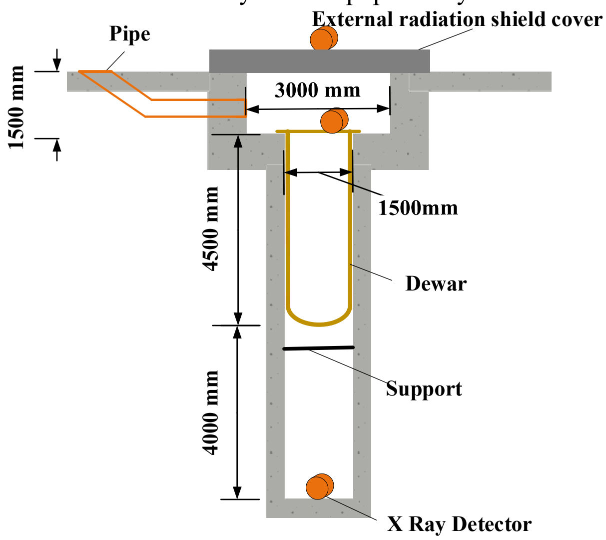

Figure 3: Diagram of vertical test pit.

Single Cavity Horizontal Test Stand

In addition to the pre-study cavity for studying the properties of superconducting materials, the superconducting cavity with the application background needs to carry out system integration research and performance test after the bare cavity vertical measurement reaches the standard in the pre-research stage. At this time, the most efficient test method is placing the integrated cavity into the universal small-scale test cryomodule, then making the mechanical and electrical signals of the tuner, the mechanical and microwave connections of the coupler, and the liquid inlet and outlet of the liquid He vessel all connected according to the operating conditions. Thereby the overall performance of the test system integration, including accelerating gradient E_{acc}, quality factor Q, tuner mechanical response curve, cavity intrinsic vibration spectrum, coupler high power characteristics and so on [4]. The success of the horizontal test largely determines whether the superconducting cavity and its related components can be mass-produced and subsequent beam experiments.

Cryomodule Horizontal Test Stand

Before the cryomodules in the engineering projects formally installed into the beam line, it needs to go through the steps of single cavity performance test, cavity string assembly, cryomodule assembly, etc. The last step is to conduct temperature reduction and high power test on the whole cryomodule to confirm its performance up to the standard. The cryomodule horizontal test is an indispensable part of any superconducting accelerator project.

Coupler Test Stand

As the most important accessory component of the superconducting cavity, the coupler also needs to be carefully cleaned, stored, installed, and must go through a long period of high-powered conditioning before it is put into formal operation to ensure it meeting the design index. The cleaning and assembly of the coupler takes place in a dedicated area of the superconducting cavity and the cryomodule clean assembly platform, while the coupler high-power test stand provides the conditions for subsequent high-power conditioning.

LAYOUT OF THE TEST PLATFORM

The layout of Superconducting Radio Frequency (SRF) Hall covers about an area of 3300 m^2 which is shown as Fig. 4. In addition to the test stands, SRF Hall also contains clean rooms, cryogenic hall and other rooms [5-7]. The vertical test system has a vertical test pit and a spare vertical test pit with a radiation shield cover (which can slide over the top of the two test pits), and only one test pit is tested at the same time. Dewar will be placed in the foundation pit (Φ1500mm×8500 mm) or the spare foundation pit (Φ2500mm×8500mm) in the future. The depth of pits does not include the height of 1500 mm from the ground. The size of horizontal test cave is 20000 mm×8000 mm.

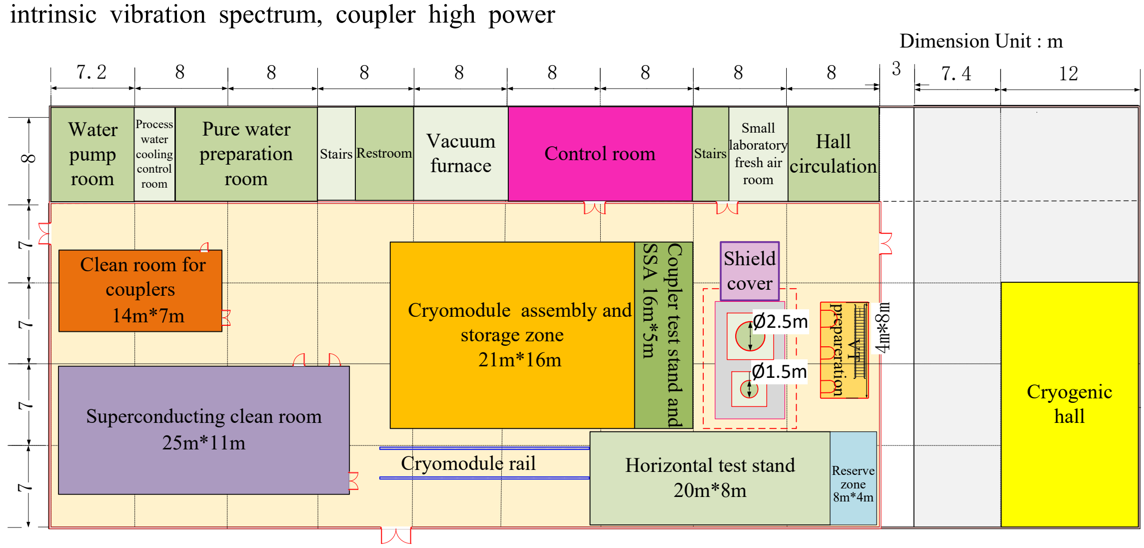

Figure 4: Layout of superconducting radio-frequency hall.

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CONCLUSION

Superconducting cavity will be adopted to radio frequency system for the beam power upgrade of CSNS and construction of the future high performance photon source in South China due to its significant advantages. Therefore we plan to build an advanced superconducting cavity test system to testing SRF cavities and cryomodules. The test platform includes vertical test stand, single cavity horizontal test stand, cryomodule horizontal test stand and coupler test stand. The construction is scheduled to begin by the end of 2019.

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