Preliminary design of superconducting cavity test platform in CSNS campus

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Introduction

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. The selected cavity types contain 324 MHz spoke cavity and 648 MHz 5 cell ellipsoidal cavity, etc. This paper will generally introduce the preliminary design of the superconducting cavity testing platform in CSNS and corresponding test parameters.

Test stands

The system function structure of CSNS superconducting cavity test platform is shown in Figure 1.

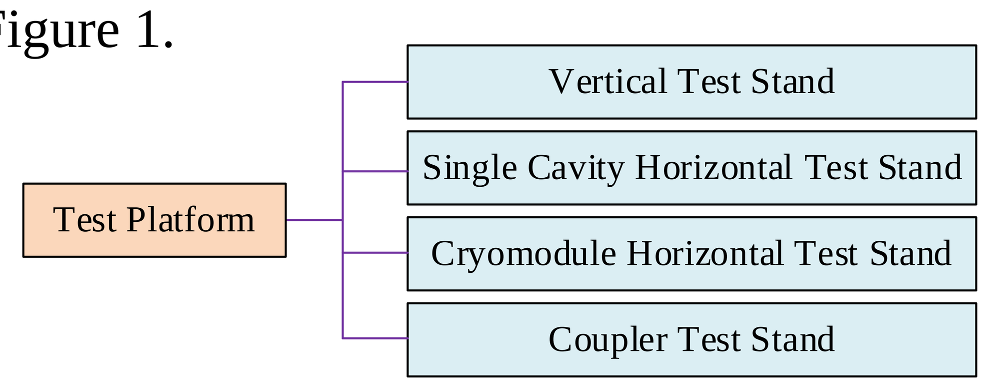

Figure 1: System function diagram

● Vertical Test Stand

The vertical test is an evaluation of the RF (radio frequency) performance at 2K or 4K temperature, after the superconducting cavity is processed and post-processed. In the VT (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. The VT 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. In addition, the inner and outer magnetic shields are used to shield the earth's magnetic field. The dewar schematic and dimensions are shown in Figure 2.

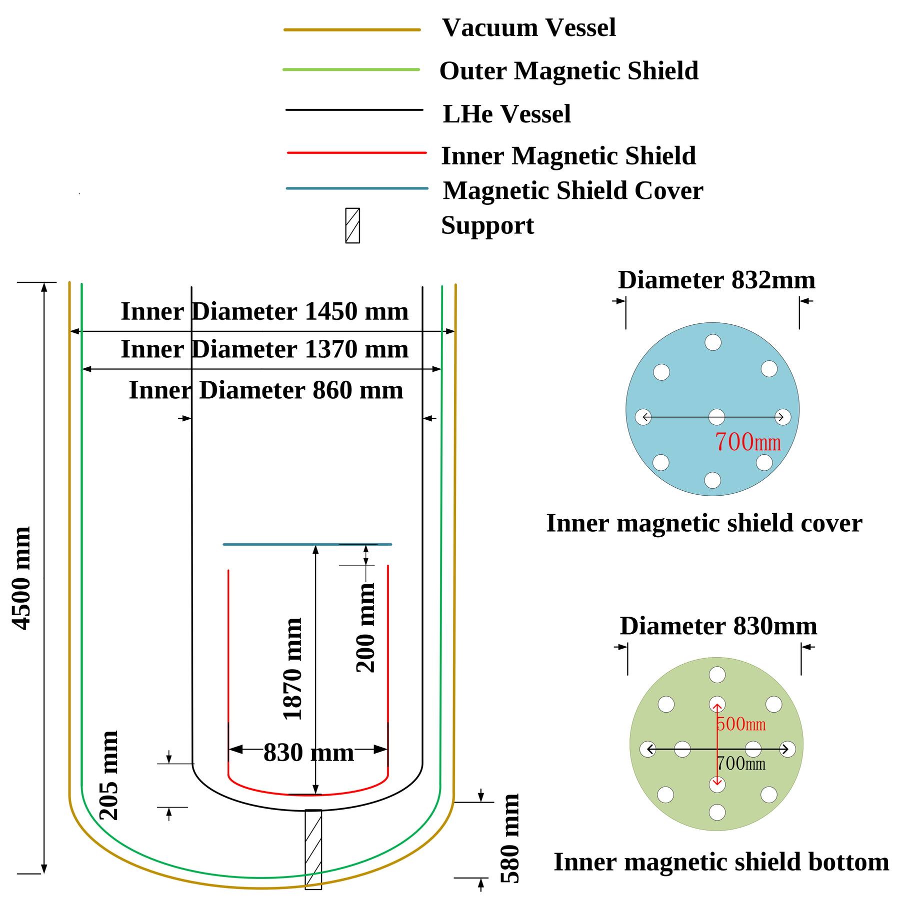

Figure 2: Vertical test dewar diagram

By referring to the design scheme of Fermilab, the vertical test pit design scheme is shown in Figure 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 dose monitor is in the vertical test 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 back-ground, 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.

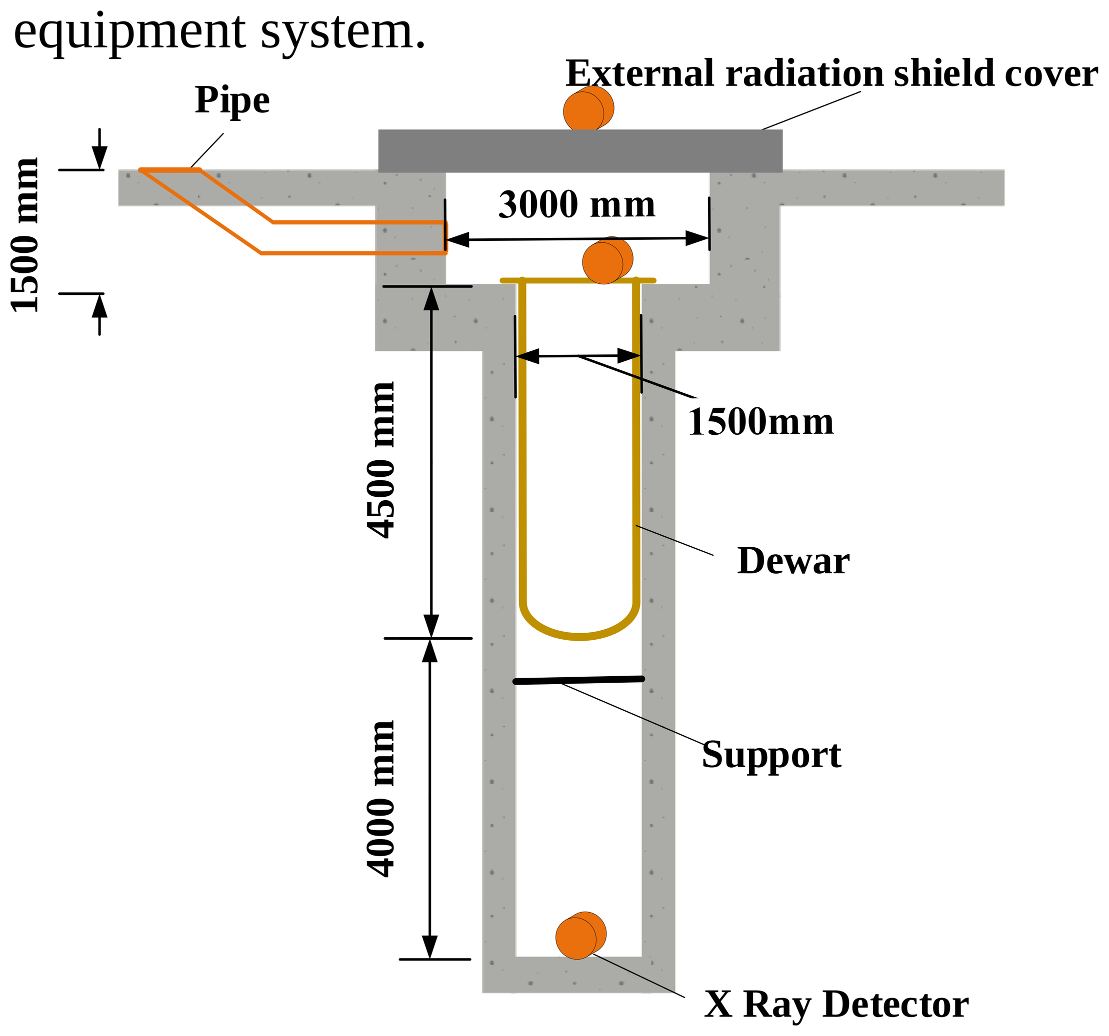

Figure 3: Diagram of vertical test pit

● 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. 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 charac teristics and so on. 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 cryomodule 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-power 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 Figure 4. In addition to the test stands, SRF Hall also contains clean rooms, cryogenic hall and other rooms. 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×8500 mm) 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.

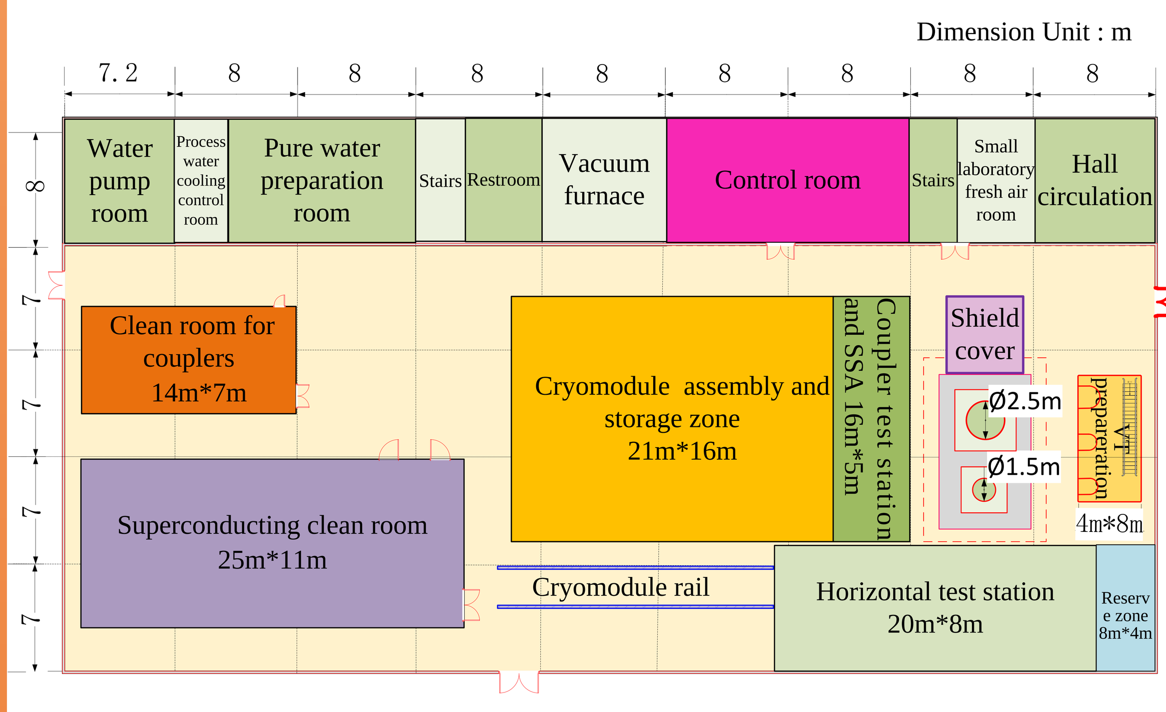

Figure 4: Layout of superconducting radio-frequency hall

Conclusion

Superconducting cavity will be adopted to radio frequency system for the beam power upgrade of CSNS and construction of the 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.