NEW POSSIBILITIES FOR SUPERCONDUCTING CAVITY TESTING AT CORNELL UNIVERSITY*

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Abstract

Cornell is testing superconducting cavities for many different purposes: system development for CESR, supporting technology transfer of CESR SRF systems to storage ring light sources around the world, collaboration with the world-wide TESLA project, collaboration with Muon Collider/Neutrino Factory projects, developing an Energy Recovery Linac (ERL) based synchrotron light source in collaboration with TJNAF, and basic cavity R&D in the areas of high Q, high field Q-slope and field emission.

For this Cornell has upgraded its preparation and test facilities and now has the capabilities to test s.c cavities with frequencies between 200 MHz and 3 GHz. Three radiation-shielded test pits have been built. The largest pit has a size of 2.4 m diameter by 4.4 meter deep. In addition to the existing RF test system at 500 MHz, 1.3 GHz and 1.5 GHz, a 200 MHz low power (2 kW) RF test system has been completed [1]. The high-power 1.3 GHz test system as well as the cavity preparation facility are presently being upgraded to incorporate TESLA 9-cell cavities. A new 1000 sq ft clean room is in operation for improved cavity preparation.

NEW FACILITIES

In a two year effort Cornell University has upgraded its cavity preparation and test facilities. A new clean room and cavity test pits give the unique capability to test superconducting RF cavities with frequencies as low as 200 MHz or a length of more than 2 m.

Cavity Test Pits

In a new cavity test area three test pits of different sizes have been excavated.

- Small test pit: 1 m diameter by 2.9 m deep for 1.5 GHz and higher frequency cavity tests.
- Medium test pit: 1.6 m diameter by 3 m deep for 500 MHz and 1.3 GHz cavity tests. A waveguide can be connected to the 1.3 GHz insert for pulsed high power tests.
- Large test pit: 2.4 m diameter by 4.4 m deep for 200 MHz and 1.3 GHz multicell cavity tests. Also this pit can be connected to the 1.3 GHz klystron for pulsed high power tests.

The small and large size pits are shown in Figure 1. A radiation shielding block with 90 tons of high density concrete can be moved over a selected pit during cavity test while the other two pits are accessible for cavity installation or removal. Up to three cavity tests within one week have been done with this new test facility.

Figure 1: Test pits for various size cavities. Shown is the small and the large pit. Not shown is the medium size pit.

Clean Room

For improved cavity preparation a new clean room with a total size of about 1000 sq ft has been installed; see Figure 2. With 262 sq ft of class 1,000 area and 704 sq ft of class 100 area this clean room allows to prepare cavities for cw performance tests and to assemble whole cryostats with a length up to about 5 m. A high temperature high vacuum furnace for cavity post-purification and a high-pressure rinsing system for cavity cleaning are placed inside the clean room.

Figure 2: New 1000 sq ft clean room.

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HPR System

A new high-pressure (up to 900 psi) water rinsing system has been built and installed in a class 100 area of the new clean room; see Figure 3. While the cavity is moving up or down, a nozzle head rotates to clean the inner cavity surface. Ultra-clean water is filtered once more directly before the nozzle head by a 0.1 μm teflon particle filter. The rinsing system has been designed to incorporate cavities from 1.5 GHz up to 500 MHz. With a travel range of about 120 cm, multicell cavities like a TESLA 9-cell cavity can be rinsed in one step.

Figure 3: New high-pressure water rinsing system.

CAVITY TEST SYSTEMS

200 MHz

The proposed neutrino factory and muon collider ask for RF cavities operating at a frequency near 200 MHz for rapid acceleration of muons [2]. One scenario is to use superconducting RF cavities [3]. The desired accelerating gradient is 17 MV/m at an unloaded quality factor of $6 \cdot 10^9$. Since there was no superconducting RF experience at 200 MHz, an R&D program was started. Two 200 MHz single cell elliptical Nb sputtered Cu cavities have been fabricated by CERN at tested at Cornell University. Figure 6 shows a 200 MHz cavity mounted on the test insert for a cw cavity performance test in the large test pit. A 2 kW cw RF amplifier is available to power the cavity during test. Several tests have be done so far; refer to [1] for details.

500 MHz

The 500 MHz cw cavity test insert with a cavity mounted is shown in Figure 6. A 500 W cw amplifier is used to drive the cavity during a performance test. In the past years this insert was used for cavity qualification tests prior to the installation of a cavity in a cryostat. In the future we plan

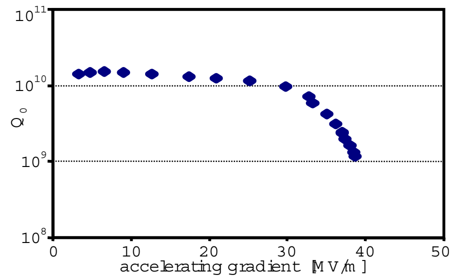

Figure 4: Cw performance of a 1.3 GHz electropolished single-cell cavity (EP done at CERN).

to test Nb sputtered 500 MHz cavities to continue the work on sputtered SRF cavities.

For a full system test a 500 MHz horizontal cryostat test facility is in operation with a 600 kW cw klystron to power the cavity. All CESR cryostats are tested to verify their performance before installing them in the CESR ring.

1300 MHz

About 10 years ago the work on s.c. 1.3 GHz cavities for the proposed TESLA linear collider was started at Cornell. A cavity test insert for low power cw test and high power pulsed test was built, see Figure 6. Via a waveguide the cavity under test can be powered from a cw 200 W amplifier or a 2 MW pulsed klystron. High peak power processing allowed to reach record high fields in the early days of these studies. Today's improved cavity preparation allows to reach high fields during a performance test without any X-rays, see for example Figure 4.

Since the "old" 1.3 GHz insert is limited to 1 to 5 cell cavities a new 1.3 GHz cavity insert with waveguide coupler is under construction; see Figure 5. This new setup will allow to test cavities with a length of up to 2 m, e.g. TESLA 9-cell cavities.

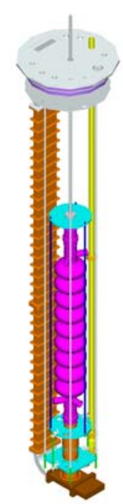

Figure 5: Sketch of the 1.3 GHz cavity insert under construction.

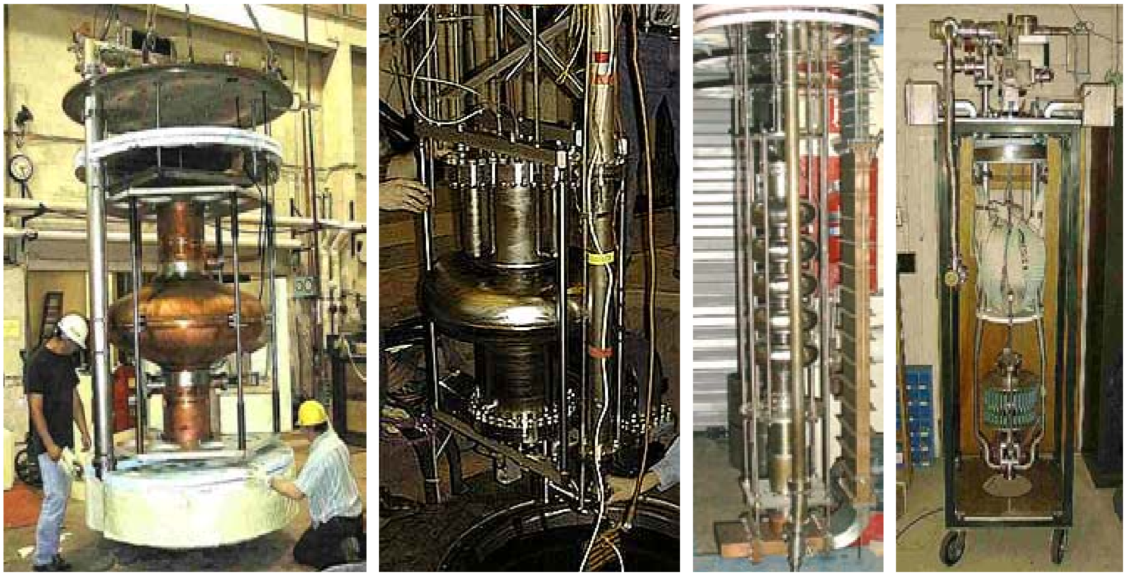

Figure 6: Cavity test inserts for various frequencies. From left to right: 200 MHz system, 500 MHz system, 1300 MHz system and 1500 MHz system.

1500 MHz

The 1500 MHz single-cell cw test system (see Figure 6) is used frequently for basic cavity R&D. With its temperature mapping system [4] it provides a powerful tool to study the high field behavior of SRF cavities. Recent studies focused on the high-field Q-drop and electropolished cavities [5].

FUTURE PLANS

Cornell will continue its work in basic SRF cavity R&D as well as in RF system development. While in the last years the primary effort of the SRF program was the development, construction, installation and operation of the 500 MHz CESR SRF system, in the upcoming years we will broaden our high gradient, high Q cavity studies for future light sources and the proposed TESLA linear collider. Cornell University, in collaboration with TJNAF, has proposed the development and construction of an Energy Recovery Linac (ERL) based synchrotron light source [6]. Such a machine offers superior x-ray beams compared to storage ring sources due to a significantly better beam quality. In order to develop the required technology and to demonstrate the feasibility of a high current, low emittance ERL we are proposing the construction of an 100 MeV, 100 mA ERL prototype at Cornell [7]. Central parts of this machine are the superconducting injector linac with 2-cell cavities and the main linac with energy recovery. Many challenges like the cw cavity operation at high gradients, HOM damping, emittance preservation, high cw power input couplers and RF field control needs attention to develop the SRF system for the ERL prototype. With the new SRF facilities we have the infrastructure to address these challenges, and work is in progress; refer to [8, 9, 10, 11, 12, 13, 14, 15].

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