DEVELOPMENT OF SUPERCONDUCTING RF FOR CESR*

S. Belomestnykh†, P. Barnes, E. Chojnacki, R. Ehrlich, W. Hartung‡, T. Hays, R. Kaplan,
J. Kirchgessner, E. Nordberg, H. Padamsee, S. Peck, P. Quigley, J. Reilly, D. Rubin, J. Sears
Laboratory of Nuclear Studies, Cornell University, Ithaca, NY 14853

Abstract

After the successful CESR beam test of August 1994 the continued development of a superconducting RF system for the CESR Luminosity Upgrade is in progress at the Laboratory of Nuclear Studies, Cornell University. The system description as well as recent results are presented.

1 INTRODUCTION

The Phase III of the CESR Luminosity Upgrade Plan [1] demands higher total beam current (up to 1 A in two beams) in order to achieve luminosity of 10^{33} $cm^{-2}sec^{-1}$. The present RF system, consisting of four 5-cell normal conducting copper cavities, can not cope with such a big current. In fact, one of the limiting factors for further increasing CESR luminosity is longitudinal multi-bunch instability due to the beam-cavity interaction [2,3].

Single-cell superconducting RF (SRF) cavities are called upon to overcome this limitation. There are two factors which achieve this goal: i) the use of superconducting cavities allows one to operate at higher gradient in each cell and therefore to use fewer accelerating cells; ii) the shape of the Cornell BB1 cell with attached beam tubes of a big diameter provides an opportunity to strongly damp higher-order modes (HOMs) and hence to decrease an impedance of the RF cavity. Thus, we have 1) lesser impedance per cell, and 2) fewer number of RF cells in the storage ring.

The detailed information about the cavity, the beam test of the cavity/cryostat module prototype, and the new RF system one can find elsewhere [4,5,6]. In this paper we describe the recent results in development of the system components.

2 SYSTEM AND COMPONENTS

The SRF system will consists of four single-cell niobium cavities [6]. Each cavity has its individual cryostat, input coupler and RF window, two ferrite HOM loads, taper transition(s) to the adjacent CESR beam tube, and some other beam-line components. New software is being developed to incorporate the SRF system into the CESR control system and to display the current status of the SRF system on the screen of X-terminal.

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† On leave from Budker Institute of Nuclear Physics, 630090 Novosibirsk, Russia

‡ Presently at Fermilab, Batavia, IL 60510

2.1 BB1 500 MHz Superconducting Cavity

Two cavities, BB1-1 and BB1-2, have been manufactured to date by Dornier and ACCEL correspondingly. Three more cavities are on order from ACCEL. The BB1-2 cavity has been tested in vertical cryostat up to design accelerating field of 6 MV/m. The preparation procedure now includes a new step: rinsing the cavity with high pressure water.

2.2 MARK II Cryostat

This new cryostat [7] has been manufactured and tested with the full size copper cavity model at Meyer Tool and Mfg. Presently the cryostat (Figures 1 and 2) has been assembled with the BB1-2 cavity at Cornell and is being tested.

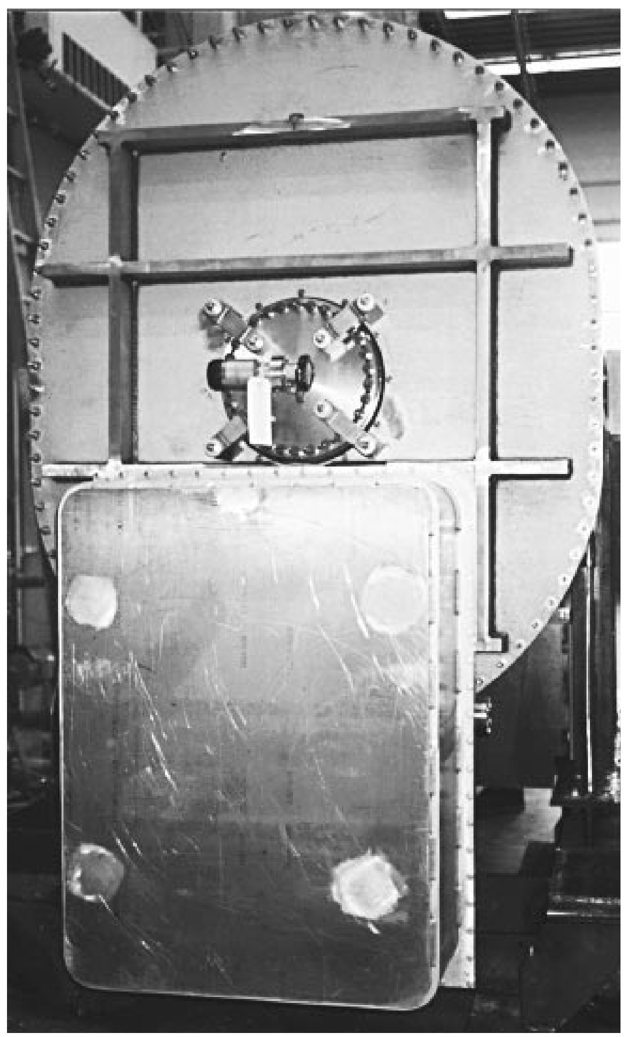

Figure: 1 MARK II cryostat: round beam tube end.

2.3 Refrigeration and Distribution

We have ordered a dedicated refrigerator system for the CESR Phase III. The first 600 W unit has been installed and tested and another 600 W system is presently being installed in parallel for the CLEO solenoid and the superconducting quadrupoles to be added near the interaction point in Phase III. Details of the refrigerator system are reported elsewhere [6].

The 2000 liter storage dewar, refrigerator output lines, transfer lines, and satellite distribution valve box for the RF processing area were installed and tested. The main and two tunnel satellite distribution valve boxes are on order and will be installed this summer.

2.4 RF Window

We have previously reported the test of the new high power RF vacuum window manufactured by Thomson [8]. Since that time we received and tested two more windows from Thomson. The new windows have been tested up to 450 kW CW (limited by the available RF power) and 520 kW pulsed at 25% duty cycle. One of the windows is used on the MARK II/BB1-2 cryostat/cavity module.

A study has been performed in collaboration with Northrop Grumman Corp. to design a waveguide vacuum window capable of propagating more than 1 MW of average RF power. Results are presented in a separate paper [9].

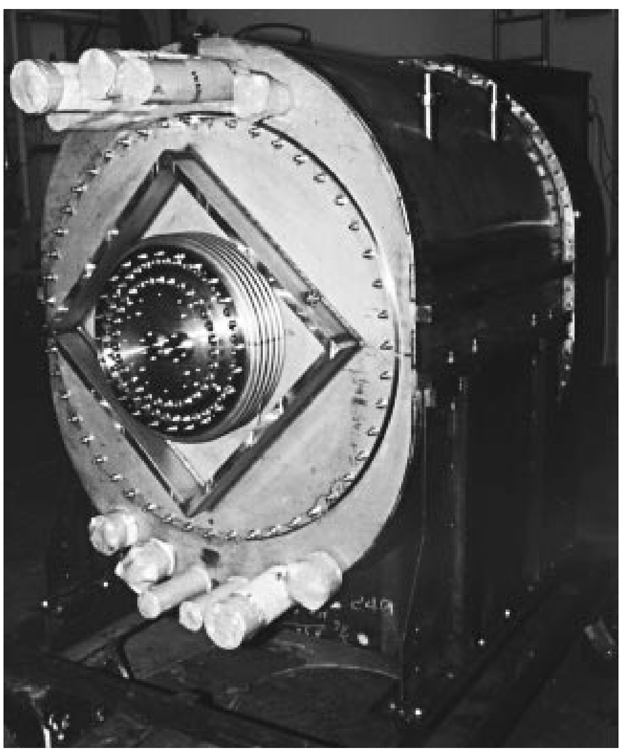

Figure: 2 MARK II cryostat: fluted beam tube end.

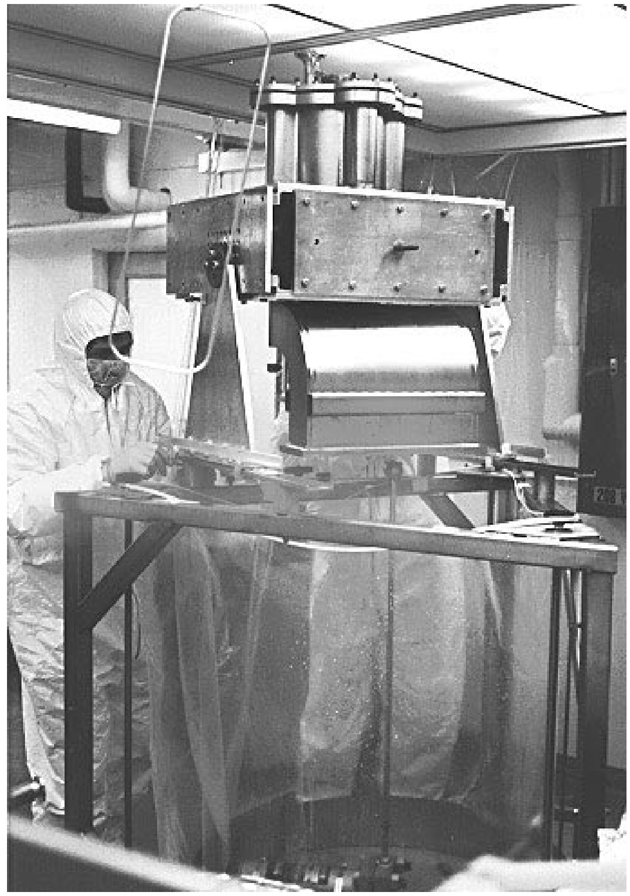

Figure: 3 BB1-2 cavity on high pressure water rinsing system.

2.5 Other Components

Following encouraging results from the TJNAF (formerly CEBAF) [10] and other labs, we developed a high pressure rinsing system as an additional step in cavity preparation. We designed our high pressure rinsing system basing on the TJNAF design. It provides 1000-1200 psi rinsing water. Qualifying tests with 1.5 and 1.3 GHz Nb cavities have been performed prior to the rinsing of the BB1-2 cavity (Figure 3).

The tuner mechanism has been changed due to the height restrictions in the tunnel. Essentially the same scheme [11] is used but with a folded, double lever arm to conserve space. The CESR III cavity/cryostat module exhibits a resonant frequency sensitivity to the helium vessel pressure of 325 kHz/Bar which is quite high value. A special pressure compensation scheme has been developed in order to decrease the sensitivity.

There will be only one cavity in the first installation so two taper transitions to the adjacent CESR beam pipes will be placed on the both sides of it. In the consequent installations, when cavities will be grouped in pairs, there will be no taper in between the cavities. The stainless steel tapers have water cooled copper synchrotron radiation absorbers welded to them.

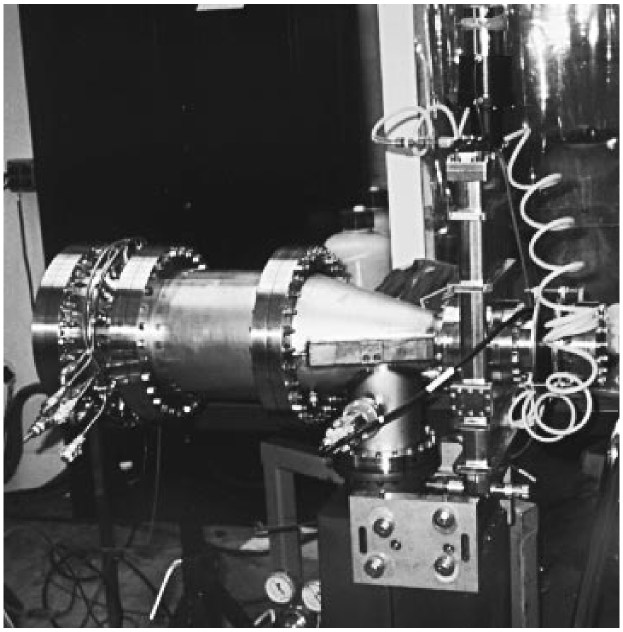

Figure: 4 Beam line assembly: HOM load, taper, gate valve and sliding joint.

3 INTERACTION WITH BEAM

At present the maximum beam current at CESR is limited by the multi-bunch beam instability [2]. Measurements [3] and calculations indicate that the higher-order modes (HOMs) in the present CESR 5-cell RF cavities are responsible for that.

In order to evaluate the threshold current of coupled-bunch instabilities due to the SRF cavities, the HOM spectrum of the SRF cavity assembly has been calculated [12] and a study of the stability of multi-bunch longitudinal oscillations in CESR has been started using the computer code MBI [13]. Preliminary results indicate that the threshold current of the instabilities is much higher than the CESR III goal.

4 SUMMARY

The first of the five cavity/cryostat systems has been assembled and is being tested now at Cornell. This module is scheduled for installation in CESR in July 1997 to replace one of the present 5-cell cavities.

All components for the rest four modules are on hands or order. We anticipate to have all components manufactured by late '97.

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