Cryostat for a Beam Test with the CESR-B Cavity,*

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I. INTRODUCTION

Superconducting cavities have been chosen as the best approach to meet the rf requirements of the proposed Cornell B-Factory. These requirements involve high beam power, low Q for higher order modes, short beamline space and low cost. The next procedure in the development program of these cavities, following the successful tests of the prototype cavity in a vertical dewar, is to place it in a horizontal cryostat in the Cornell Electron Storage Ring and test under operational conditions with circulating beams. A later step in the upgrade of CESR before the switchover to a B-Factory will be to place four such cavities in the ring as the accelerating cavities for circulating beams of 2 x 500 mA. The B-Factory will require twelve cavities in the high energy ring (1A) and four in the low energy ring (2A), see Table 1.

Table 1
SUPERCONDUCTING RF FOR CESR-B

	High Energy Ring	Common	Low Energy Ring
Luminosity $(cm^{-2}\ s^{-1})$		10^{33}	
Energy (GeV)	8.0		3.5
Beam Current (A)	0.9		2.0
Number of Cavities	12		4
Total Required Voltage (MV)	35		12
Synch. Rad. Power (MW)	4.5		1.5
Volts per Cavity (MV)	2.9		3.0
Load H O M Power (kW)	4-5		14-24
Cavity Beam Power (kW)	380		400
Cavity Dissipation at 4K (W)	100		
Q-Value		10^9	
Frequency (MHz)		500	
Tuner range (+/-kHz)		400	

*Supported by the National Science Foundation, with supplementary support under the U. S. - Japan Agreement.
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Initial design concepts for the prototype cryostat were developed in drawings by the authors. These concepts included layouts of the beamline and waveguide components, bellows for accomodating thermal contractions and misalignments, helium and vacuum vessels and other needed features. On the basis of these drawings and other specifications we circulated a request for proposal and Meyer Tool and Mfg., Oak Lawn, Ill. were the successful bidder. Meyer Tool have completed engineering calculations, created fabrication drawings and are in the process of constructing the cryosat. Figure 1 shows their assembly drawing of the cryostat and cavity. Since this is a prototype and we expect to disassemble it several times, a design with O-rings and indium seals is chosen. We expect design modifications for the final production cryostats, one of which may be to use grindable welds in the helium vessel. Another modification will involve the rf waveguide, which, in the prototype test location, need not clear the low ceiling of the CESR tunnel.

In the order for the prototype niobium cavity from Dornier GmbH., Friedrichshafen, Germany, we also purchased a copper version with identical mechanical dimensions in order to make rf and mechanical tests.[1] We plan to augment this cavity with the thermal transitions constructed at Cornell and complete the initial assembly at Meyer Tool with this subassembly. Complete vacuum, pressure, LN2 temperature and other mechanical tests will be performed with this unit. Low power rf tests will be performed with this unit after it is shipped to Cornell. The reassembly with the niobium cavity will be done at Cornell in clean room conditions. This system will be tested at low power first, then moved to a test location with full rf power available and finally moved again to CESR for beam tests.

II. THERMAL TRANSITION PIECES

Within the vacuum envelope of the cryostat are thermal transition pieces on the two beampipes and the waveguide designed to keep radiation and conduction to the liquid helium bath to a low level.[2] The beamline transition pieces are of the same cross section as the ends of the niobium cavity, round on one end and fluted on the other end. They are made of 1 mm thick stainless steel plated on the inside with 1.3 microns of copper and are 24 cm long with LN2 intercepts 8 cm from the room temperature ends. They do not incorporate gaseous helium heat exchangers at the 4K ends.

The thermal transition for the waveguide does incorporate a gaseous helium heat exchanger to help carry away the heat generated in the walls by the high incoming rf power . The passages in this heat exchanger are formed by expanding double wall stainless steel sheets on each of the four sides. This unit is 25 cm long and is plated on the inside with 1.3 microns of copper. The next portion of the waveguide, the 90 degree elbow, is held at LN2 temperature, thus greatly cutting the thermal radiation load within the waveguide to the cavity. In addition the specular reflection of radiation from the room temperature portion of the waveguide to the cavity is reduced by shaping the internal surface of the elbow such that the 300K radiation cannot reach the helium bath via a single reflection. This elbow is heavily plated with 6 microns of copper since it is at a uniform temperature. The final portion of the waveguide within the cryostat is the vertical section 25 cm long, going from LN2 to room temperature. The rf vacuum window is in a section of waveguide just above the cryostat.[3]

The calculated radiation and conduction heat loads of the thermal transition pieces are included in Table 2. The range of values for radiation depends on the assumption of the ratio of specular to diffuse reflection on the internal copper plated surfaces.[2]

III.EXTERNAL BEAM LINE COMPONENTS

In both directions along the beam line outside the cryostat are the components consisting of the higher order mode loads, sliding joints, gate valves, and round section, water cooled pipes of diameter 24 cm and length 24 cm. They are designed to absorb the calculated HOM power of 24 kW each in the worst case.[4] Outside these loads will be sliding joints, also of the full 24 cm diameter as required in the B-Factory. These fittings consist of silver plated rf

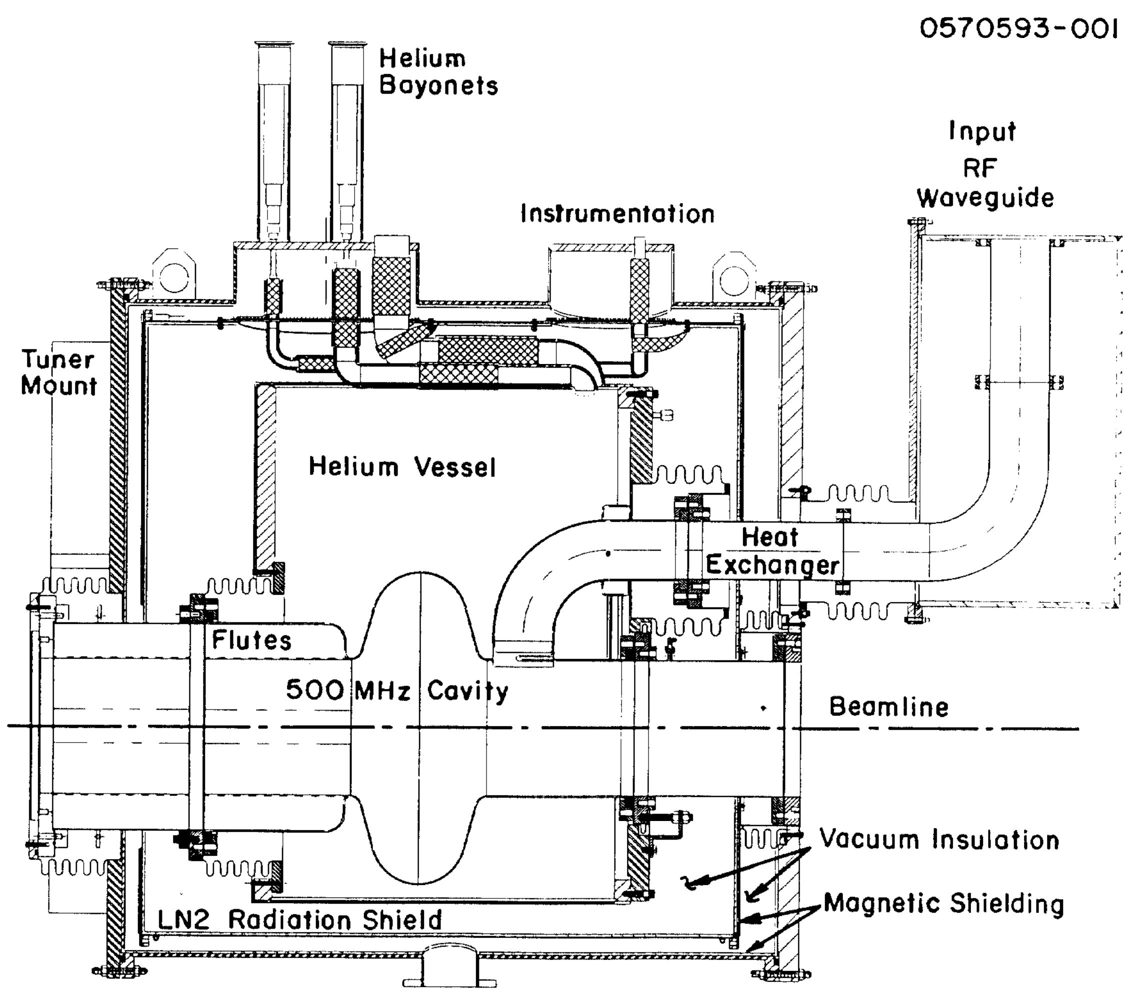

Figure 1. Assembly Drawing (Elevation) of the Cryostat for the CESR-B Cavity

finger stock sliding on copper plated stainless steel which is surrounded by a bellows vacuum seal. Their axial range is 25 mm and they allow angular adjustment but no radial offset. Next in line are specially designed rf shielded gate valves. These have been designed and constructed in cooperation with MDC Vacuum Products, Hayward, California as rf shielded versions of their 24 cm diameter gate valves. Outside these valves are tapered sections taking the beam pipes from the cavity diameter down to the existing beampipe sizes, which happen to be about 7 cm by 12 cm in the section of CESR selected for the test. These tapered sections are needed to minimize HOM power generation from the circulating beams. They have rf shielded pumping ports to which 270 l/s noble diode, ion pumps are attached. Two additional 60 l/s pumps are located on the waveguide for pumping the cavity during operations when the gate valves are closed.

Table 2
CALCULATED HEAT LOSSES (Watts)

	To Liquid Helium Radiation	To Liquid Helium Conduction	To LN2
Round Pipe	3.3 to 5.1	3.8	38
Fluted Pipe	3.4 to 5.3	6.5	65
Waveguide	0.1 to 0.2	2.0	55
LHe Vessel	0.1		
Supports		0.3	3
Bayonets		4.8	
Ports		0.4	4
LN2 shield			25
Totals	8.8	17.8	190
R.F. Dissipation	100		
Grand Total	127		

IV. TUNER

The required range of tuning of the cavity during operation in CESR is 400 KHz in order to detune the cavity sufficiently to prevent unwanted excitation of the cavity by the coasting CESR beam. The bandwidth of the cavity at the planned Q_{ext} of 2×10^5 will be 2.5 kHz with a resolution of the order of 1 Hz. The cavity will be tuned by mechanically stretching the cavity along the beam line relative to the cryostat. The tuning coefficient of the cell is measured to be 390 kHz/mm with a required force due to the cavity alone of 7100 N/mm. Added to this force is the hydrostatic force of 22000 N of the cryostat. The tuner has been designed for +/- 1 mm at 45,000 N. The drive train will consist of a stepping motor, a 100:1 harmonic drive speed reducer, and a ball screw. This is followed by a 10:1 lever arm terminating in a dual parallel flex hinge arrangement patterned after the proposed LANL PILAC cavity tuner.[5] Such a mechanism has been built and tested. The advantage of such a flexible linkage system is that there are no bearings with the inherent alignment and backlash problems.

V. INSTRUMENTATION AND CONTROL

Within the cryostat are rf probes located on the thermal transition pieces and waveguide near the cavity. The cavity itself does not have any penetrations for instrumentation. Temperature monitors, a liquid helium level gauge and heaters are the only other internal instrumentation. All other devices are external, such as, helium vessel pressure relief and gauge, helium liquid input and gaseous output flow control valves, the LN2 control valve, the tuner and various other rf monitors. A hard-wired interlock system will shut down the power from the rf klystron in case of rf, vacuum or beam related mishaps.

VI. REFERENCES

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