FABRICATION AND INSTALLATION OF SUPERCONDUCTING ACCELERATOR MODULES FOR THE ERL PROTOTYPE (ERLP) AT DARESBURY

Peter vom Stein, Stefan Bauer, Michael Pekeler,
Hanspeter Vogel, ACCEL, Bergisch Gladbach, Germany,
Robert Bate, Carl David Beard, Douglas M. Dykes, Peter McIntosh, Brian Todd,
CCLRC/DL/ASTeC, Daresbury, Warrington, Cheshire, United Kingdom

Abstract

Installation and commissioning of the superconducting energy recovery linac (ERL) prototype is under way at Daresbury Laboratory [1]. ACCEL have manufactured two superconducting accelerator modules for the injector and the linac, operating at 2K with 1.3 GHz TESLA type cavities. Each module contains two cavities and is designed to provide an accelerating voltage of 25 MV in cw mode. This paper presents details of the module fabrication, cavity preparation and performance results. An overview of the cryogenic installations for the modules is given and status results of the commissioning are discussed.

MODULE DESIGN

The superconducting bi-cavity modules (Fig. 1) are optimized for operation in cw mode with moderate beam currents. The module design has been developed at Forschungszentrum Rossendorf and is used under a license agreement. ACCEL performs beside the module integration the whole cavity manufacturing and preparation including guaranteed performance values (Table 1). Each module is equipped with two TESLA type cavities, which run at 2 K in superfluid helium. Both cavities are mechanical coupled to a rigid string, which improves the stiffness against microphonic oscillations. The diameter of the two phase helium line connection to the helium tank is increased compared to the TESLA design to improve the performance with high dynamic rf losses.

Table 1: Basic parameters srf bi-cavity module

RF frequency	1300 MHz
Operating temperature	2 K
Accelerating gradient	15 MV/m guaranteed 20 MV/m goal
Q_0 @ 15 MV/m	$5x10^9$
Rf power per coupler	8 kW cw
Stand by losses	<15 W
Length (flange to flange)	3.26 m

The power capability of the rf input coupler is approx. 10 kW cw per cavity. The thermal shield of the module is cooled by liquid nitrogen at atmospheric pressure. The magnetic shielding is at room temperature metal and made of mu-metal sheets housed at the inner side of the vacuum vessel.

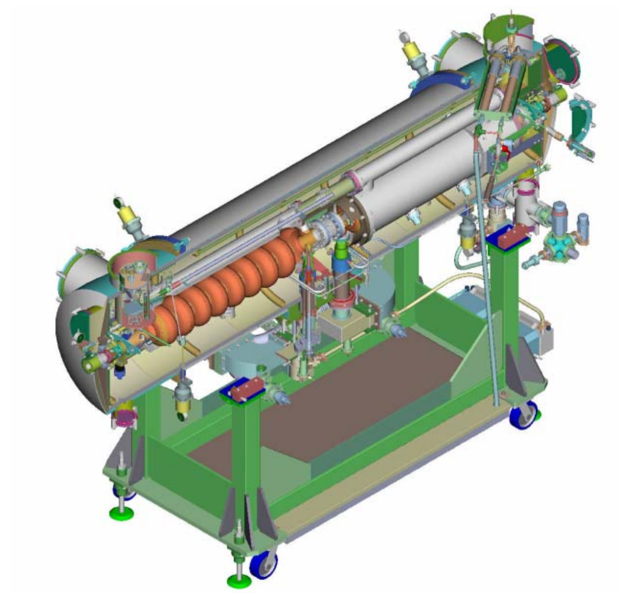


Figure 1: SRF bi-cavity module (courtesy FZ-Rossendorf)

PARTS FABRICATION

All rf key components of the module including cavities and power couplers are manufactured at ACCEL workshops. The cavity fabrication follows the established standards for the TESLA type high gradient cavities. The pretuning of cavity half cells and the final field flatness tuning was done in house.

Figure 2: Power couplers after brazing

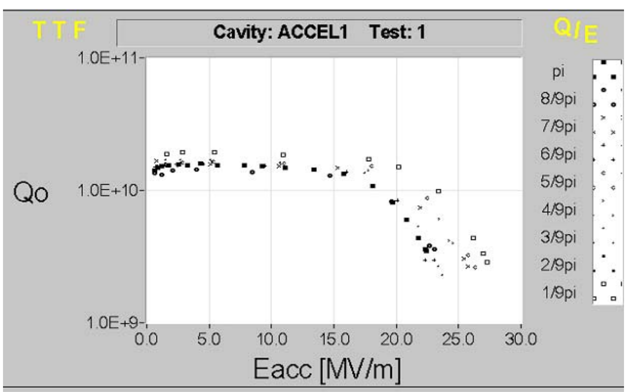
The power couplers are brazed in a high vacuum, high temperature process. Before installation the couplers undergo an additional rf processing, which was done at FZ Rossendorf.

The TESLA HOM coupler rf alumina feedthrough was exchanged by a sapphire feedthrough to improve the thermal conductivity at 2K. This intends to lower the thermal load on the HOM coupler antennas at cw operation.

CAVITY PREPARATION AND TESTS

The chemical surface preparation and high pressure rinsing of the TESLA type cavities has been performed at ACCEL. The surface chemistry is done with the standard Buffered Chemical Polishing (BCP 1:1:2). The chemistry is applied to the cavity in a closed acid cycle with temperature control to avoid hydrogen diffusion into the Niobium material. The interior surface of the cavity is cleaned by high pressure water rinsing (HPR).

After cavity preparation the cold rf test of the cavity was done at DESY. Fig. 3 shows the results of the cold rf test for cavity ACCEL 1. After some rf processing the cavity reached a Q_0 of more 2×10^{10} at 20MV/m.



mode / cell	pi	8/9pi	7/9pi	6/9pi	5/9pi	4/9pi	3/9pi	2/9pi	1/9pi
1&9	22.42	23.06	24.20	23.09	20.16	16.06	11.85	7.81	4.74
2&8	22.42	20.28	12.87	0.00	13.16	21.64	23.71	19.77	13.65
3&7	22.42	15.05	4.47	23.09	24.73	8.55	11.85	22.48	20.92
4&6	22.42	8.01	19.73	23.09	4.57	24.61	11.85	14.67	25.66
5	22.42	0.00	25.75	0.00	26.32	0.00	23.71	0.00	27.31
Limit:	PWR	BD	PWR	PWR	PWR	BD	PWR	PWR	PWR

Figure 3: Results vertical rf test at DESY.

MODULE ASSEMBLY AND STATUS

After passing the vertical test the cavities return to ACCEL. Here the cavities are equipped with the helium vessels and undergo a further interior surface cleaning step. Then the cavities go into the clean room for the further mounting of the cold coupler windows and feedthroughs. Inside the cleanroom the cavities are flanged together with other beamline components and finally build up a rigid, hermetically sealed cavity string.

The following assembly steps can be accomplished at ACCEL´s standard working areas, where the other main components like vacuum vessel, magnetic shield and thermal shielding are preassembled. These main components are installed into the outer vacuum vessel starting with the outer magnetic shielding up to in inner cavity string.

Figure 4: Cryomodule II ready for shipment at ACCEL.

After assembly the cryomodules undergo a cold factory acceptance test. There the cryomodules are cooled down to 4.2 K with liquid Helium at atmospheric pressure. This allows to check the vacuum integrity of the isolation and beamline vacuum at low temperature levels. Besides that the cold cavity frequency, tuning range and the external Q values of the power coupler and HOM couplers are checked.

The first cryomodule was finished in end of March 2006. The cryomodule was transported from Germany to England by air ride trucks through the channel tunnel to avoid severe impacts by marine transport. The second module was finished in June 06 and currently waits for the transport to Daresbury Laboratory. After delivery of the 2[nd] module the cryogenic commissioning on site will start.

INSTALLATION AND COMMISSIONING

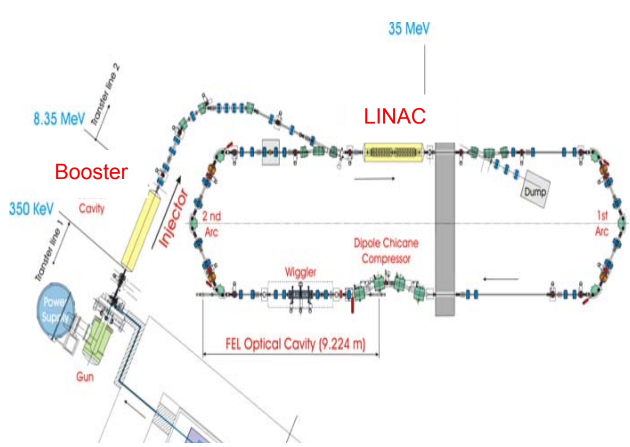


Figure 5: ERLP Layout.

Fig. 5 shows the layout of the ERLP showing the locations of the cryomodules for booster cavities and the LINAC. It is estimated that the overall cooling power required to keep both the cryomodules at 2K will be about 150 W. This will be achieved by a cryogenic system (Fig. 6) consisting of Linde TCF-50 helium liquefier, a 2K cold box and two vacuum pumps (connected in parallel) with total pumping capacity of 13700 m^3/hr. The 4K liquefier (Linde TCF-50) has just been commissioned (Fig. 7) and we will be moving into the next phase of commissioning the cryomodules and the 2K system.

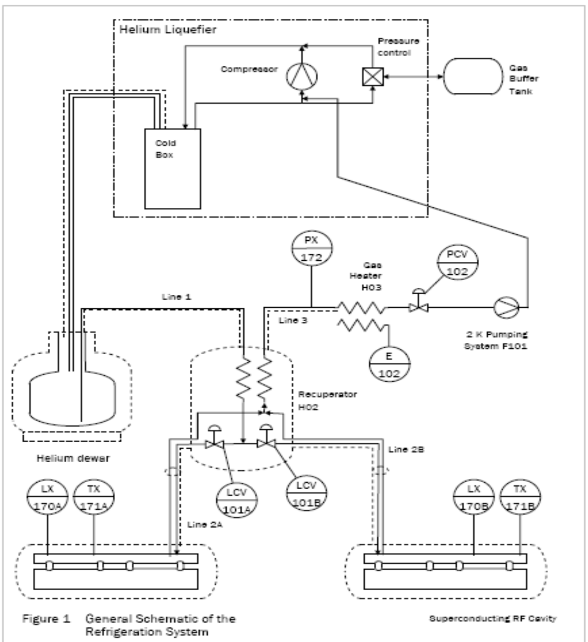


Figure 6: ERLP Cryogenics layout.

Figure 7: Commissioning of the ERLP Cryogenics.

Figure 8: Delivery of Cryomodule I at Daresbury.

The cryomodule I for the injector has been delivered at Daresbury (see Fig. 8) and the cryomodule II (Fig. 1) is ready for shipment. The SRF cryomodule is a key component of the ERLP which will be used as a test bed to investigate the new technology of 'energy recovery' and CW operation, and resolve many issues specifically identified for the development of 4GLS [3].

REFERENCES

[1] M.W.Poole et al.,"4GLS: A New Prototype of Fourth Generation Light Source Facility", PAC 2003, Portland, May 2003, p.189.

[2] A. Büchner et al.,"The ELBE-Project at Dresden-Rossendorf", EPAC 2000, Vienna, June 2003, p. 732.

[3] S.Pattalwar et al., "Key Cryogenics Challenges in the development of the 4GLS", EPAC 2006, (MOPCH187).