

## DESIGN OF HIGH POWER INPUT COUPLER FOR CORNELL ERL INJECTOR CAVITIES\*

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### Abstract

A 75 kW CW coupler for superconducting injector cavities of Cornell ERL project has been designed. The coupler has variable coupling.  $Q_{ext}$  varies from  $9.2 \times 10^4$  to  $8.2 \times 10^5$ . The prototype TTF-III TESLA coupler design has been revised to a great extent. Cooling of critical parts has been radically improved. The new design is close to be multipacting-free. The coupler design is presented, as well as results of its thermal analysis. Possible schemes of high power tests are discussed.

### INTRODUCTION

The Energy Recovery Linac (ERL) – a challenging ultra-high brightness X-ray source of a new generation – is the future, post-CESR project of Cornell University [1]. It should be a CW 5 GeV machine with a high average current (100 mA). Superconducting 1300 MHz RF structures will be used in the main linac and injector of this project. Building of the prototype of this machine [2], [3] has started at Cornell. The Phase 1a of the prototype includes a DC photoemission electron gun, a copper buncher cavity, an injector cryomodule with five superconducting two-cell cavities, and a beam dump.

The input coupler is one of the key components of the injector cavities due to strict requirements such as a high CW power transferred to the beam (up to 100 kW), strong coupling, wide range of coupling adjustment, and small distortion of transverse beam motion.

To meet these requirements, each cavity will be equipped with a twin coaxial coupler [4], consisting of two identical antenna type couplers symmetrically attached to a beam pipe of the cavity (see Figure 1). This is a remedy to reduce RF power per single coupler, coupling to the cavity, and the transverse kick to the beam.

### COUPLER DESIGN

The design of single couplers is derived from the TTF III input coupler [5]. It was, however, significantly updated.

1. The cold part was completely redesigned using a 62 mm, 60  $\Omega$  coaxial line (instead of a 40 mm, 70  $\Omega$  line) for stronger coupling, better power handling and avoiding multipacting.

2. The antenna tip was enlarged and shaped for stronger coupling.

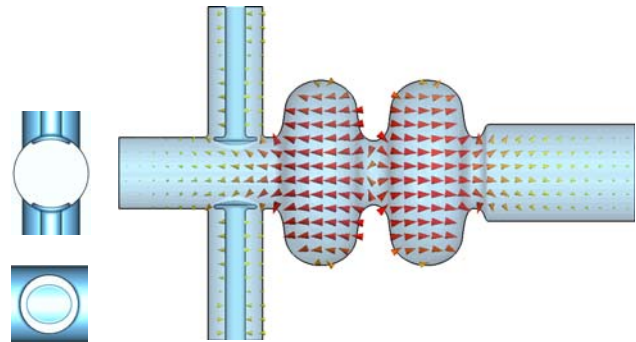


Figure 1: Input coupler in the injector cavity.

3. The “cold” window was enlarged to the size of “warm” window.

4. The outer conductor bellows design (both in warm and cold coaxial lines) was improved for better cooling: more heat intercepts were introduced.

5. Forced air cooling of the warm inner conductor bellows was added.

The parameters of single couplers for the injector cavities are summarized in Table 1. The general design of the coupler is shown in Figure 2.

Bellows were the critical parts of TTF-III coupler at high CW power levels. Both estimates and tests [6] showed excessive heating of the bellows. Introduction of an additional 80 K intercept for cold bellows and a 300 K intercept for warm bellows in the outer tube of coaxial lines as well as forced air cooling of the bellows in the inner tube of coaxial line gave a significant decrease of bellows temperatures.

Table 1: Parameters of a Single Coupler

Central frequency	1300 MHz
Bandwidth	$\pm 10$ MHz
Maximum RF power transferred to matched load	75 kW
Number of ceramic windows	2
$Q_{ext}$ range	$9.2 \times 10^4$ to $8.2 \times 10^5$
Cold coaxial line impedance	60 $\Omega$
Warm coaxial line impedance	46 $\Omega$
Coaxial line OD	62 mm
Antenna stroke	$\geq 15$ mm
Heat leak to 2 K	$< 0.2$ W
Heat leak to 5 K	$< 3$ W
Heat leak to 80 K	$< 75$ W

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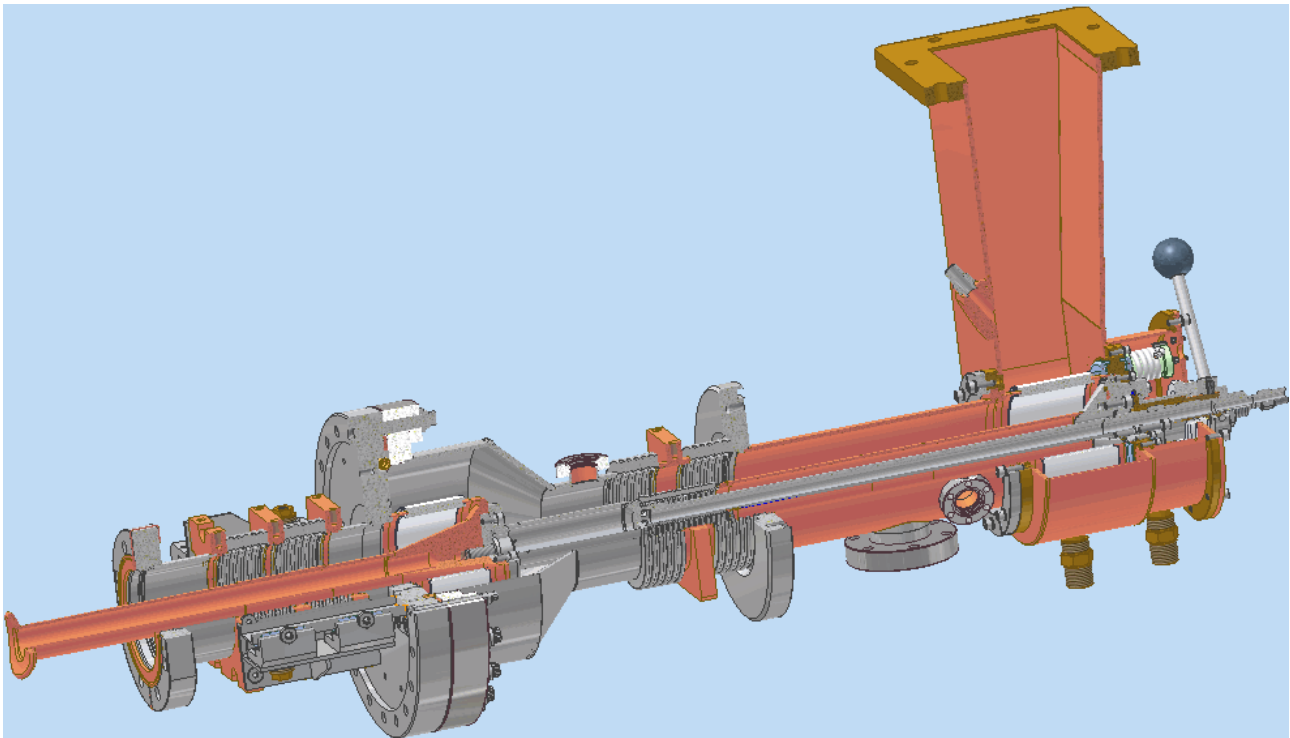


Figure 2: 3D view of the injector cavity coupler.

In Figure 3 a temperature map of the coupler for a traveling power of 75 kW is shown and Figure 4 presents the temperature distribution along bellows. One can see that the bellows temperature does not exceed 380 K.

Figure 5 shows the  $S_{11}$  parameter of the coupler in a frequency range for different coupling values (due to different bellows' extension/compression). The value of  $dl$  corresponds to the antenna travel relative to the middle position. Geometry of the coupler is optimized for obtaining compromised low reflection in the whole range of coupling variation.

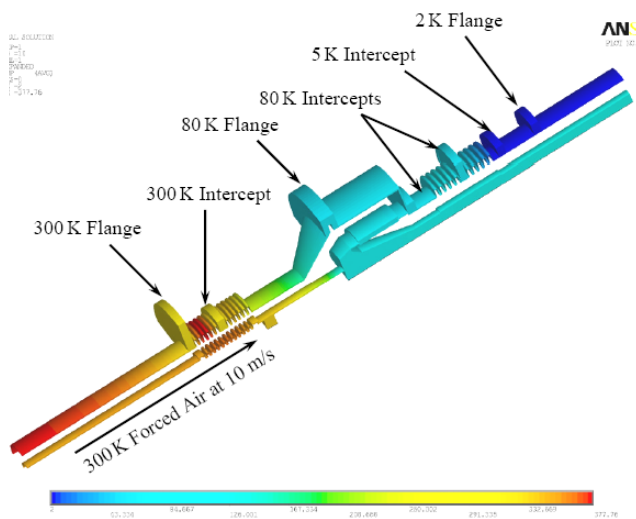
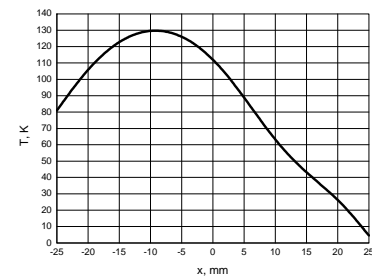
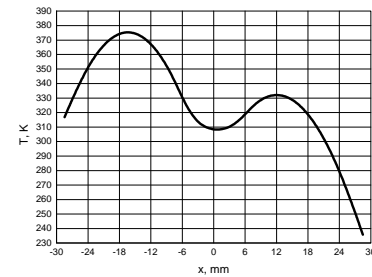


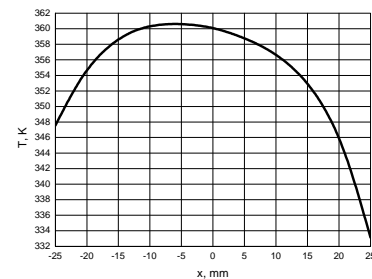
Figure 3: Temperature map of the coupler (results of ANSYS simulations).



a)



b)



c)

Figure 4: Temperature distribution at 75 kW CW in traveling wave along: a) cold bellows, b) warm outer conductor bellows, and c) warm inner conductor bellows.

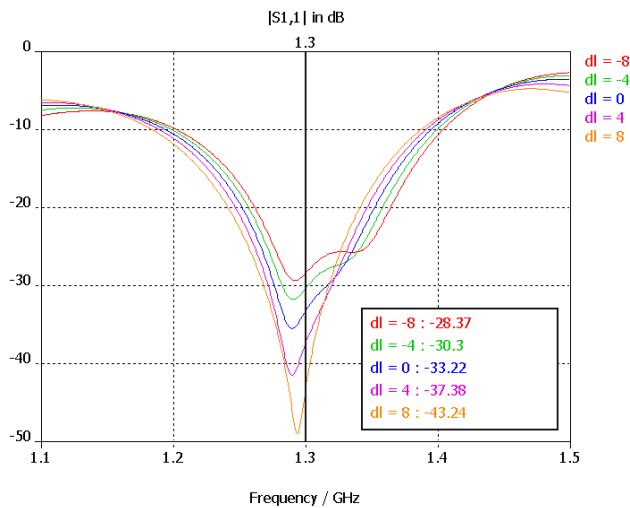


Figure 5: Reflection of the coupler in a frequency range at different coupling (coupling increases from weak to strong when  $dl$  varies from  $-8$  mm to  $+8$  mm).

## PLANS FOR HIGH POWER TESTS

We plan to test the couplers in conditions close to the real ones. For this purpose we will build a nitrogen cryostat with a copper coupling cavity inside. The whole cold part of couplers will be cooled to 80 K.

Figure 6 shows the assembly of this test nitrogen cryostat with a coupling cavity and two couplers. One coupler will be connected to the high power CW klystron and a water cooled load will be attached to the other coupler.

If no high power klystron is available by the time of the tests, a resonant ring set-up will be build and the two couplers assembly will be inserted into the ring. A power gain of 40 is expected in the ring. Therefore, a moderate power RF transmitter could be used for the tests in that case. Most likely it will be a 15 kW CW IOT.

## CONCLUSION

The input coupler design for ERL injector cavity is complete. Building of the couplers has been ordered from CPI/Beverly. The first two couplers are scheduled to be delivered to Cornell for tests in the beginning of 2006.

## REFERENCES

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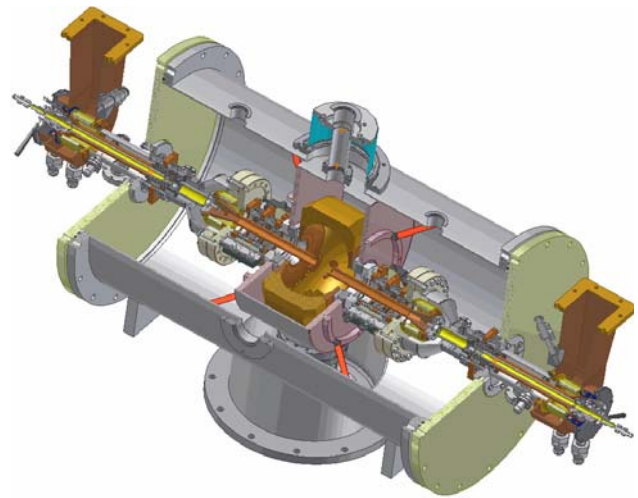


Figure 6: Nitrogen cryostat with coupling cavity and two couplers for tests.

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