NB PROTOTYPE OF THE SUPERSTRUCTURE FOR THE TESLA LINEAR COLLIDER

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Abstract

In this paper technical details of the first Nb prototype of a superstructure made of four 7-cell sub-units with non-resonant coupling are presented. Arguments for the proposed technical solutions of some critical components (the superconducting flange connection, the tuner, HOM couplers, the input coupler) and their possible influence on the performance of the Nb prototype are commented. The prototype should be tested with a beam at the beginning of 2001. The very short time forces us to use many of the existing components with only minor technical modification to perform “proof of principle” test. The most expensive part is the cryostat, which will be adapted and re-assembled after this test for the standard 8 cavities made of 9 cells, to build a spare cryomodule for the TTF linac.

1 INTRODUCTION

The Nb prototype of the superstructure, a different layout of cavities arrangement in the linac, based on non resonantly coupled sub-units [1, 2], is extensively studied at DESY since January 1999. The proposed layout gains the fill factor in the machine and increases by a factor of 3 the number of cells fed by one input coupler. These make the superstructure to be an option promising a cost reduction and an improvement in the performance of the collider [3]. The chosen coupling method leaves enough space between cavities to put HOM couplers between sub-units for damping of dangerous parasitic modes and to put pickup probes to control field flatness in the super-structure. It will be partially corrected during operation since each sub-unit will be equipped with a tuner.

Many existing components and tools constructed for the 9-cell cavities will be used to build the first prototype and to carry out the first experiment with the beam in TTF linac. This is due to the very short time we have to prepare the first prototype for the beam test (January 2001) and to be able to incorporate results of the test in the Technical Proposal of the TESLA collider.

2 SUB-UNITS

The prototype will be built of four 7-cell cavities. The first cavity in the chain (type I) will be equipped with a port for an input coupler (IC). The other three (type II) are without the port and are identical. We are planning to fabricate 6 cavities: two of type I and four of type II. The selection of the best four cavities will be done after the vertical test of all six units. The cavities of both types assembled in the LHe vessel are shown in Fig. 1.

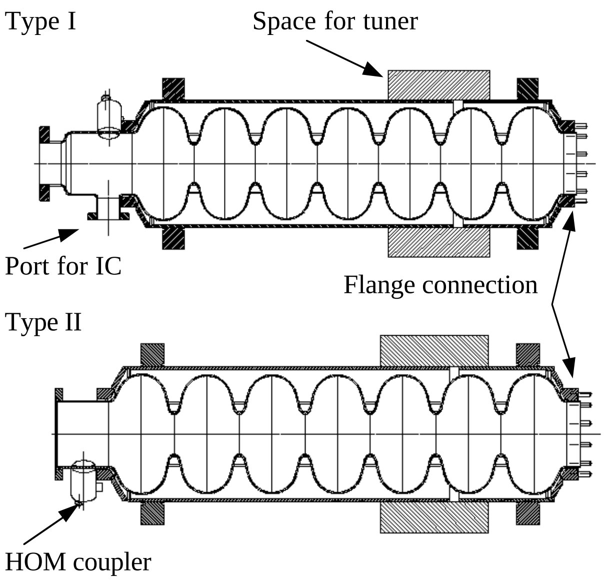

Figure 1: Two types of sub-units

2.1 Flange connection

The cavities will be jointed in the chain with help of a superconducting flange connection. The flanges are made of NbTi. The sealing ring is made of low RRR Nb and has a polygonal cross-section. This joint has been proposed to avoid additional development of a new welding technique which would allow to assemble four carefully cleaned and already tested cavities without pollution of their inner surface. It is clear to us that this is not a final solution. For the TESLA collider a new welding technique, less expensive and more reliable for 20000 cavities, must be developed and tested.

A single cell cavity with the proposed joint is under prepa-ration to estimate experimentally additional cryogenic losses at different accelerating gradients. The test will be carried out in November this year.

2.2 Tuner

At present the interconnection between cavities is $3/2\lambda$. This contributes very strongly to the low value of the fill factor. The tuner used now for 9-cell TTF cavities is placed at the interconnection and occupies more than 1/3 of its length. This makes 2.3 km of the beam line useless for acceleration. The proposed tuner, which can be used for TTF cavities as well, will be placed on the LHe vessel [4]. The vessel will be made of two parts connected by bellows, Fig.2. The outer edges of both parts will be welded to conical end plates, which will be EB welded to the end beam tubes. By rotation of the mid part of the tuning tube, the length of the LHe vessel (and cavity) can be changed and the frequency may be adjusted. The expected tuning range will be ± 1.5 mm. This provides a frequency range of ± 600 kHz. The expected resolution will be 10 Hz. The model of the tuner will be built and tested by the end of this year.

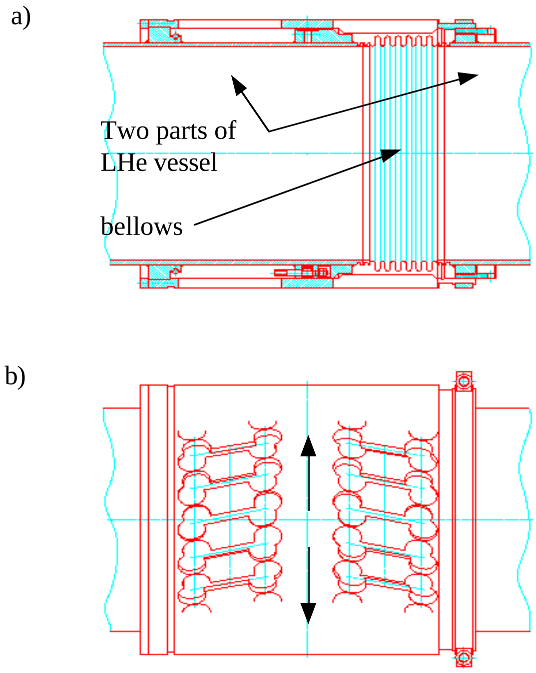

Figure 2: New tuner placed on the LHe vessel. a) the cross-section, b) the tuning tube, arrows show rotation directions

2.3 *Input coupler*

The input couplers based on 40 mm coaxial line showed a power capability of 1.6 MW for the whole TESLA pulse [5]. The last coupler version (called TTF-DESY III), with a cylindrical warm window at the coax-waveguide transition, is under fabrication and will be tested in the next year. This coupler will be used to power the Nb prototype of the superstructure because there is almost no change in the coupler construction needed for the assembly in a cryomodule. The required Qext of the coupler, providing reflection free operation, can be reached when the penetration of the antenna tip in the beam tube is about 6 mm. The coupler is shown in Fig. 3. The conditioning of the coupler to high power level is usually time consuming mainly because of the multipacting phenomena. Since the lower order levels of multipacting scale with forth power of the coax diameter it is worthwhile to increase the diameter of the coupler. This and the power requirements for the TESLA operation at gradients higher than 25 MV/m are the reasons to base the input coupler at least on a 60 mm line in the future. An alternative way is to use a rectangular waveguide coupler.

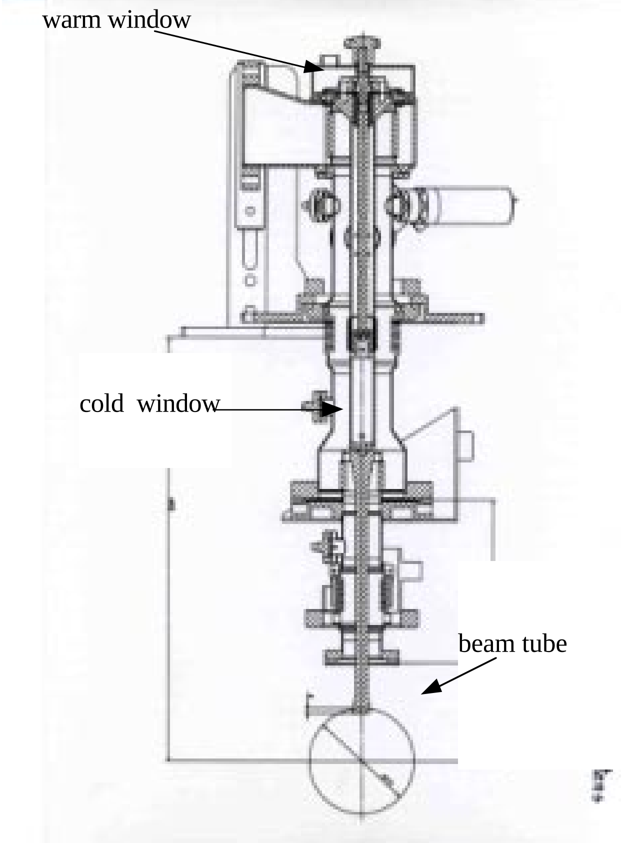

Figure 3: Input coupler, DESY-TTF III

2.4 *HOM coupler*

The distance between two sub-units is 115 mm to provide synchronism between bunches and the accelerating field. Part of this space is occupied by the flange connection, which, as it has been mentioned above, is a solution thought only for the prototype. The left space allows to attach to the interconnection a HOM coupler based on a coaxial line of diameter not bigger than 40 mm. Because of that we have decided to use for this experiment the welded version of HOM couplers designed for 9-cell TTF cavities. To provide enough damping of the most dangerous modes the electric antenna of the coupler has been made longer by 5 mm [6]. With the longer antenna tip we achieved very good damping for many modes but for some of them Qext was near to the BBU limit [7]. We plan to equip the superstructure with 5 HOM couplers, three will be attached to the interconnecting tubes and two will be attached to both end tubes. For the future we are developing a HOM coupler based on bigger diameter coaxial line to have more margin in the HOM damping.

3 VERTICAL TEST

All 6 cavities will be tested in the vertical cryostat to control the quality of their fabrication and the cleaning procedure. The existing cryostats constructed for 9-cell cavities can be used without modification for the high Q test of 7-cell cavities. The only difference is that 7-cell cavities have shorter end beam tubes: 24 mm on one side and 90 mm on the other side. To keep the field profile of the accelerating mode, two special superconducting end cups have been constructed to perform this test. Both cups are shown in Fig. 4. The expected field profile and the contour of the arrangement are shown in the Fig.5

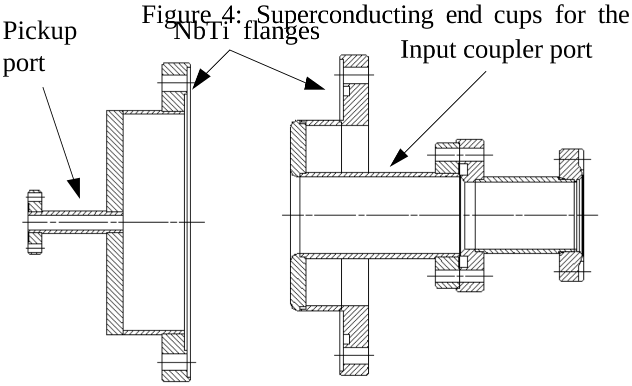

Figure 4: Superconducting end cups for the high Q test, (left) cup with port for the pickup probe for the shorter end tube, (right) cup with port for the variable input coupler, for the longer end beam tube.

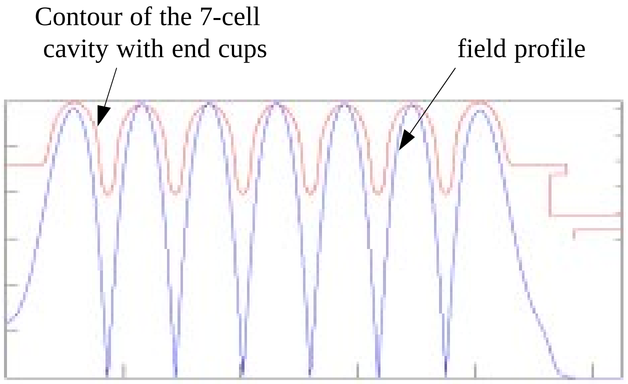

Figure 5. Computed field profile of 7-cell cavity with both end cups.

4 ASSEMBLY IN THE CRYOSTAT

The most expensive part of the set-up for the test with a beam would be a special cryostat housing the Nb prototype of the superstructure. In two years from now TTF linac will be mainly operated as a free electron laser facility. To avoid long breaks in the operation if one of the cryomodules must be repaired it has been decided to build one additional cryomodule. We will adapt the cryostat of this spare cryomodule for the superstructure experiment. The cryostat, which will be delivered in October 2000, will have additional sliding supports for the superstructure (Fig. 6). The whole chain will have fixed point in the cryostat at the IC position. Since the interconnections are now stiff and without bellows, tuning of an individual sub-unit will change the length of the whole chain and thus will move all sub-units together. The sliding plates, which are welded to each LHe vessel, move on the needle bearings with small residual friction. In the worst case the friction causes that tuning of one cavity may detune the others by 45 Hz [8]. This detuning can be easily corrected with the tuners.

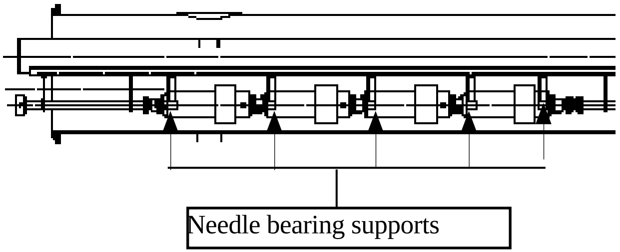

Figure 6: Four sub-units in the cryostat.

The superstructure is 4.02 m long. A dummy tube will fill up the rest of the space, about 8 m, in the cryostat. We are not going to put standard 9-cell cavities in the remaining space to avoid any misinterpretation of the observed results.

Another difference from 9-cell structures is that each sub-unit will have 2 pickup probes, one on each side, to monitor field flatness during the experiment. For this purpose pickups must be well calibrated.

In case the beam test will show that we can use the superstructure for the TESLA collider, one has to design a new longer cryostat which can house 3 or even 4 superstructures to conserve the gain in the fill factor.

5 SUMMARY

All components for the beam test are now under study or in production. It seems realistic to us to perform the beam experiment in January 2001. The experiment should prove the computed energy spread and show the excitation of the parasitic modes and their interaction with accelerated particles. Also field adjustment during operation and for the HPP processing can be checked for the cold Nb prototype of the superstructure.

6 ACKNOWLEDGMENT

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7 REFERENCES

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