

# Matched Input/Output Cavities of W-Band Muffin-Tin WBAND-003

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*This paper is part 4 of a group of papers for the first TU-Berlin structure WBAND-003*

## **Abstract**

*This Paper presents different possibilities for a design of an input/output coupler for a linear accelerating structure. It is part of the design of the first TU-Berlin W-band accelerating structure WBAND-003.*

## I. Introduction

An input/output coupler is, simply said, necessary to get fields in the structure. The coupler, the first and the last cells of a structure, the so called coupling cells, need to be matched. What does that mean? We have to adjust different geometry parameters, so that we get as low as possible reflection at the aimed frequency, as well as the aimed group velocity which is proportional to the bandwidth. Another important point is the strength of coupling and matched Q-values.

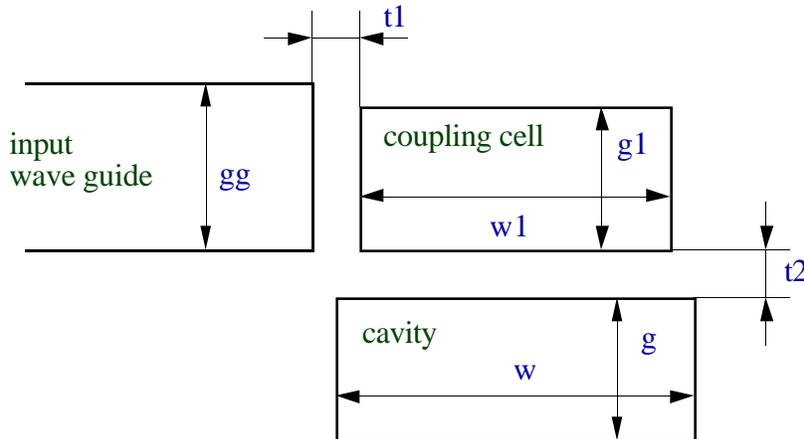
During an attempt to match such a coupler by modifying different geometry parameters, we see that after matching one criterion all the others are completely detuned. This means, that it is a very time consuming work, because all parameters work together.

Generally we have the standard cavity geometry parameters free for adjusting. Not all of them, because one limitation is that we get a really planar structure with only one depth. So the depth of the cavity ( $2b$ ) is not free, also the aperture can not be changed. The inner cavities are optimized for maximum shunt impedance, so it would be bad to change RF characteristics by changing the aperture. All general parameters are listed in figure 1. Generally you have only the coupling cell width  $w_1$ , length  $g_1$ , wave guide width  $gg$  and the thickness of the coupling iris  $t_1$  available. Sometimes it is helpful to increase the iris  $t_2$  to match the external Q - value. The values of  $w$  and  $g$  are fixed.

After a long study of matching couplers and a lot of different attempts and methods that failed, this paper presents three different successful couplers matches.

For all matching attempts a use of only four cells is enough. The advantage is a short calculation time

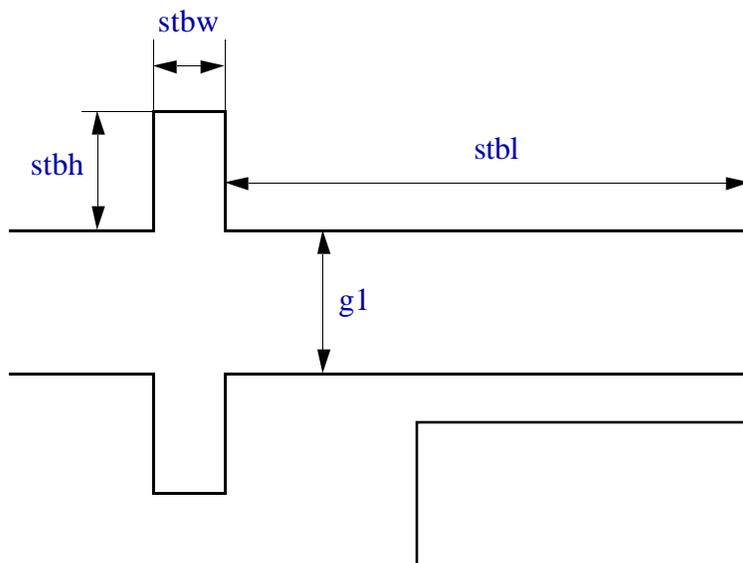
which is really necessary (it needs a lot of attempts until a structure is tuned and matched). After the coupler is matched well, the number of accelerating cells will be increased to the aimed number ( $N=7$ ). This leads to a detuning and a very long calculation time. The detuning can be corrected with few new calculations. After this is done, we can increase the number of grid cells to get a more accurate result. This causes a very long calculation time and a further small detuning and so new calculations follow.



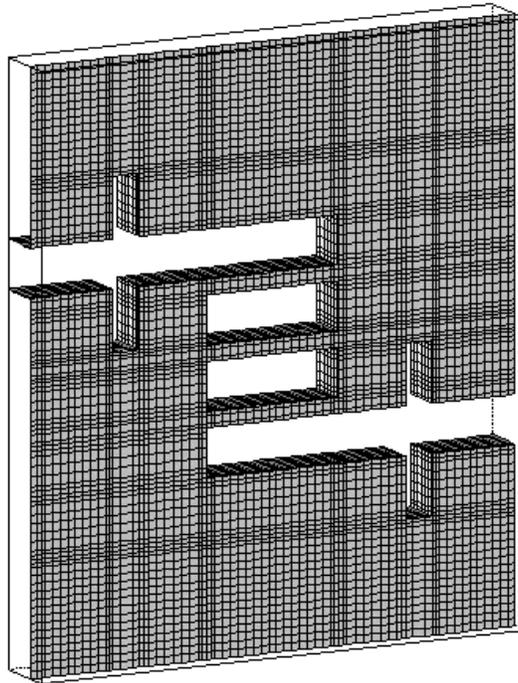
**FIGURE 1.** General geometry parameter.

## II. Matching with a double stub line tuner

Figure 2 shows the geometry of a standard double stub line tuner. We can use the width STBW, the height STBH and the length STBL of the coupler and the length  $g1$  of the coupling cavity to adjust and modify the behavior of the coupler. These two stub line tuners are fine to adjust the bandwidth and the coupling. It is not a big deal to tune such a coupler. The problem is always the strength of coupling, what means that everything is under coupled.

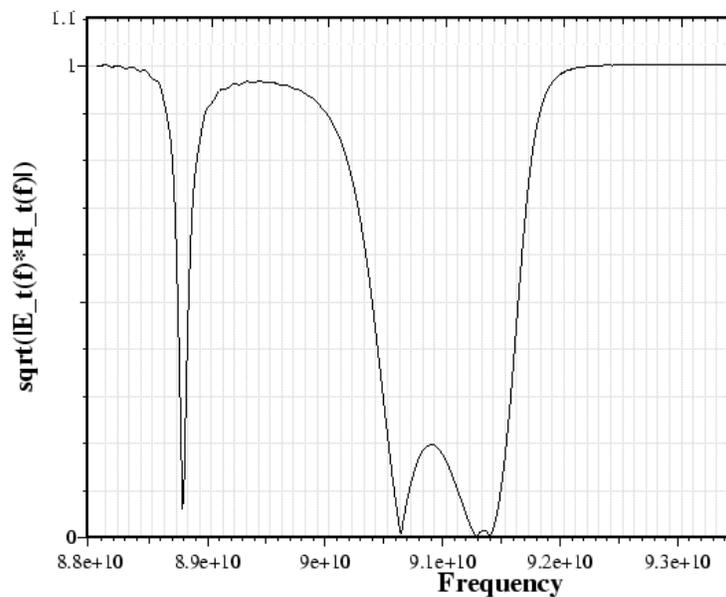


**FIGURE 2.** Free parameters of the double stub line tuner.

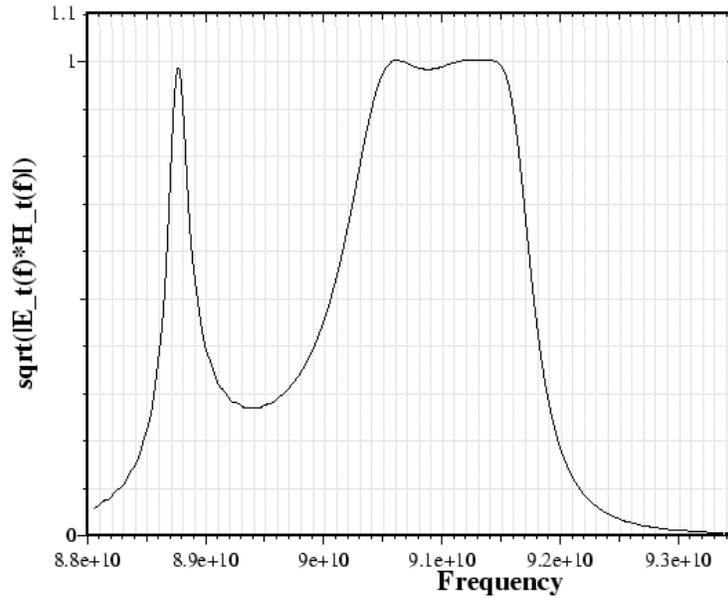


**FIGURE 3.** GdfidL model of the double stub line tuner.

In figure 3 the GdfidL model of a four cell test structure is shown. Many attempts are done with different combinations of STBL, STBH and STBW to find a good match. The best results of the simulation we could get are presented in figure 4 -5. There you can see a under coupled situation, but tuned for the aimed frequency. The advantage of this structure is that it is really full planar with only one depth. The disadvantage is small bandwidth in the ambiency of the aimed frequency.



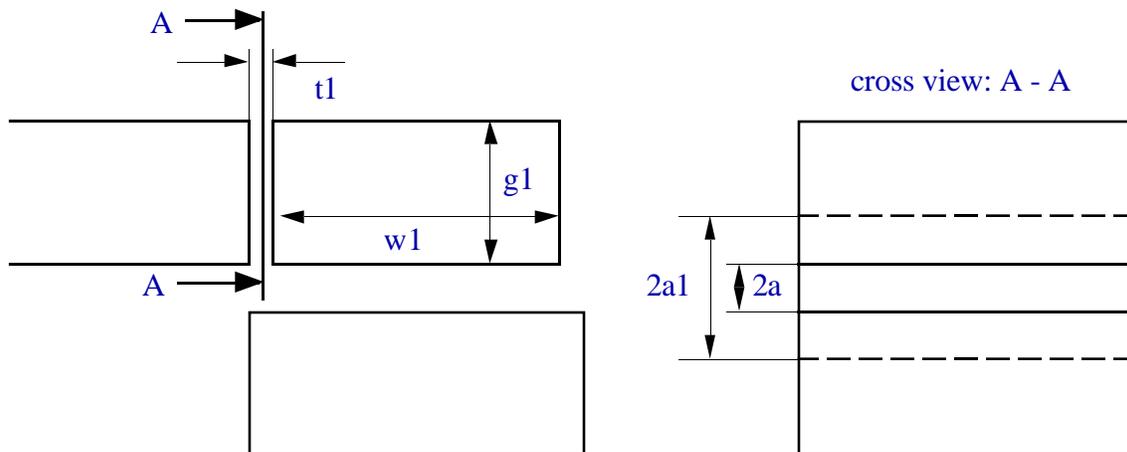
**FIGURE 4.**  $S_{11}$  chart of the double stub line tuner.



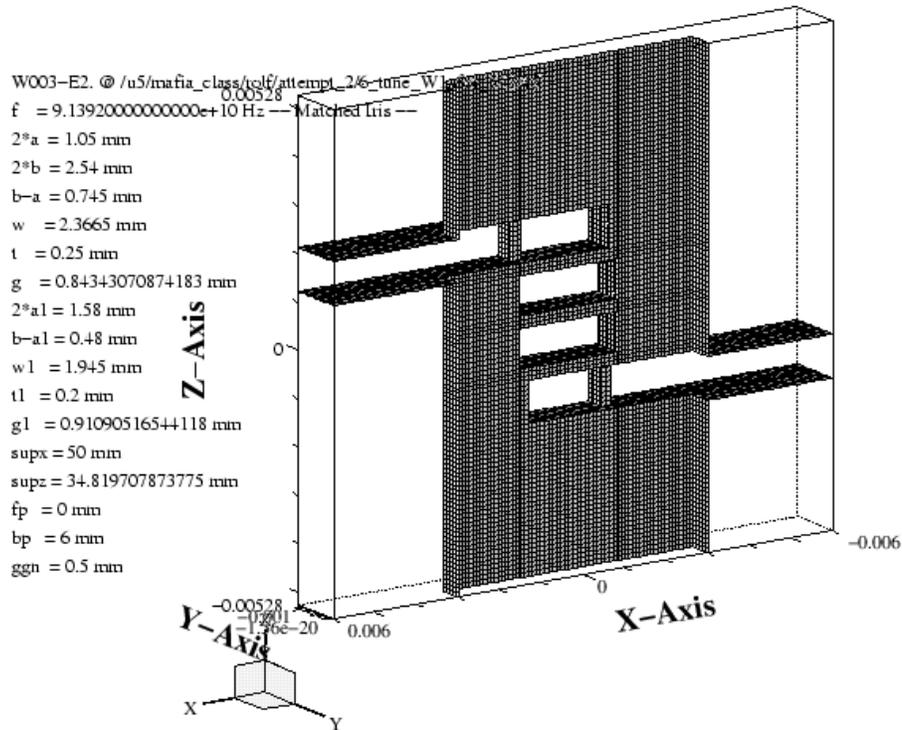
**FIGURE 5.**  $S_{12}$  chart of the double stub line tuner.

### III. Matching with a cut iris

Figure 6 shows the geometry of the cut iris. We have two depths, the standard aperture  $2a$  and the new aperture  $2a_1$  over the coupling iris. We can use the coupling cavity length  $g_1$ , the cavity width  $w_1$ , the thickness of the coupling iris  $t_1$  and height of the coupling aperture  $2a_1$  to adjust and modify the behavior of the coupler. This method was the only one which worked, what means that we got enough coupling and we could match the external  $Q$ . The parameters  $a_1$  and  $t_1$  are very helpful to increase the coupling. For  $t_1$  there is unfortunately a technological limitation. So it makes no sense to decrease  $t_1$  to a value which is not realizable. The thinnest chosen value was a thickness of 0.2 mm. After we found a good coupling it was easy to tune this structure for 91.392 GHz by modifying the parameters  $w_1$  and  $g_1$ . If we realize this method, we brake our limitation and we will get a two depth structure which is not easy to realize, but however, time is short, let us go this way and we will find a solution.

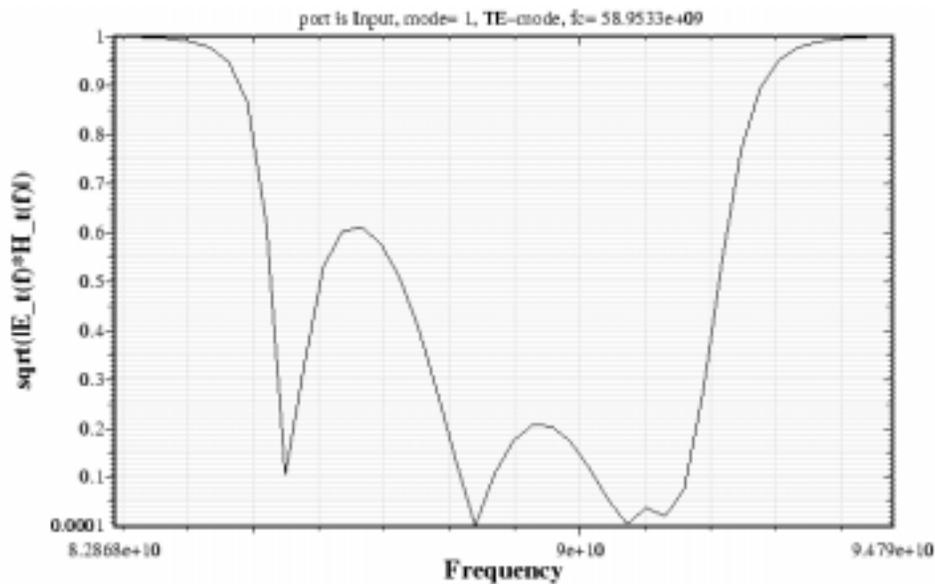


**FIGURE 6.** Free parameters of the cut iris.

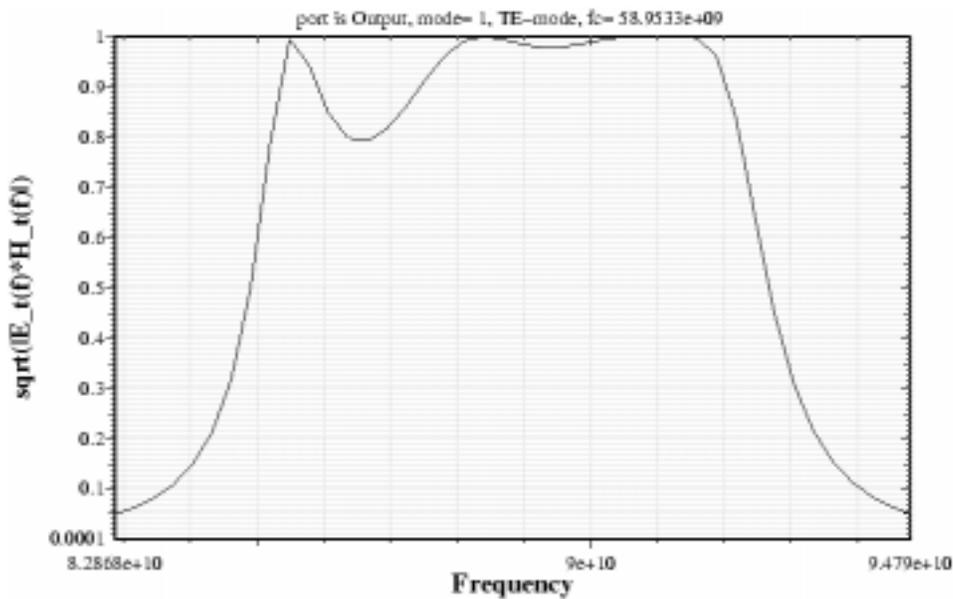


**FIGURE 7.** GdfidL model of the cut iris.

In figure 7 the GdfidL model of a four cell test structure is shown. The best results of the simulation we could get, are presented in figure 8-9. If you allow such a second depth, it is not a big deal to match a structure. It is a nearly perfect match, perfect coupled and perfect tuned for the aimed frequency, but the disadvantage is this sucking second depth of the coupling iris 2a1, as shown in figure 6. The S parameter charts you can see, are not really perfect. After a few attempts more with a higher number of grid cells it would be looking perfect, but why spend more work and time in a structure we can't realize ?



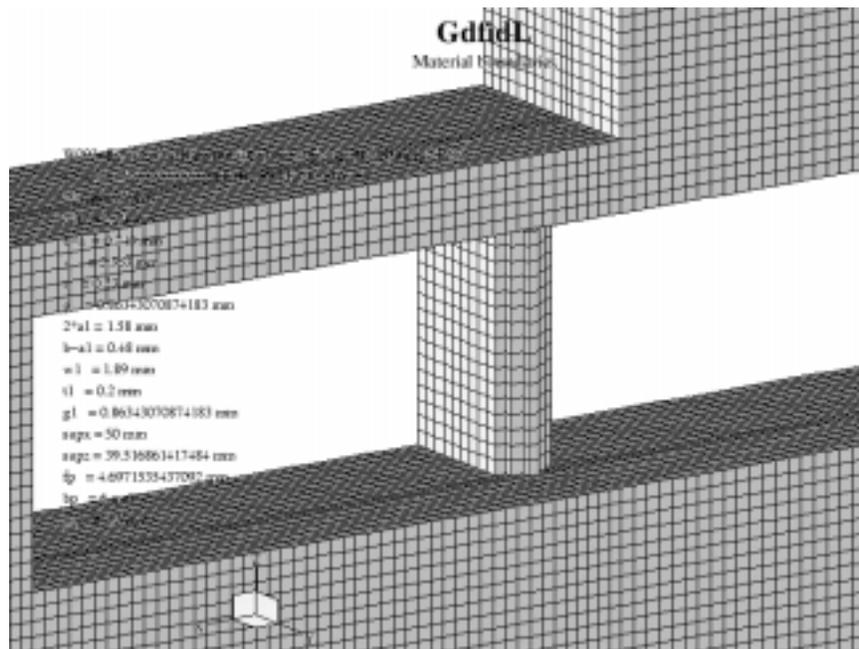
**FIGURE 8.** S<sub>11</sub> chart of the cut iris.



**FIGURE 9.**  $S_{12}$  chart of the cut iris.

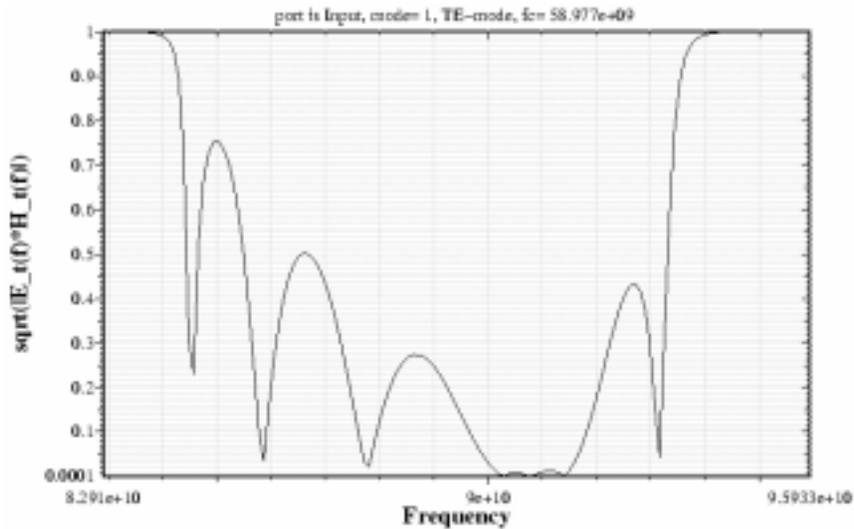
#### IV. Matching with a diagonally cut iris

As said, we have found a way to match a coupler but we can't realize this method with the fabrication technology we would use at this time. After some coffees and cigarettes (sorry, I'm a German !) and a lot of discussions, we<sup>1</sup> found a way to realize this with the aimed fabrication technology, the so called EDM. The way how to do this is presented in [1]. Figure 10 shows a zoom of this diagonally cut iris area. The complete model looks like the one figure 7.

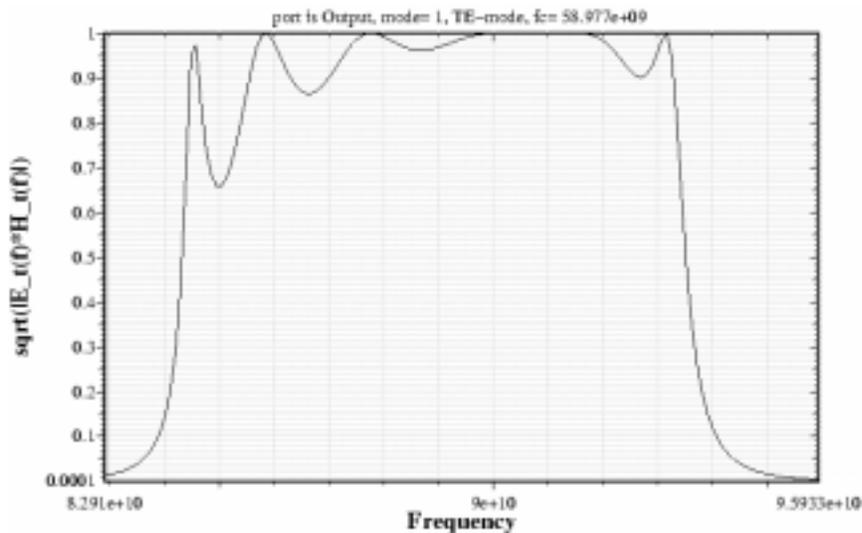


**FIGURE 10.** Zoom of the diagonally cut iris.

<sup>1</sup> special thanks to **Dennis Palmer**, who had this great idea !



**FIGURE 11.**  $S_{11}$  chart of the diagonally cut iris with  $N=7$  cells.



**FIGURE 12.**  $S_{12}$  chart of the diagonally cut iris with  $N=7$  cells.

After this match was found, several special analysis were done, for example a study how sensitive this match is for different angles of the iris roof. This is necessary because it is not sure that after a EDM cut we really get the simulated angle. It looks pretty good. That angle is not very sensitive, but the resulting height of the coupling aperture. A few 10 micrometers and the structure is detuned, which results in a higher reflection and lower transmission. I will continue this work and I hope that in the close future we will get a real one depth coupler and coupling cell ! All points I learned during these attempts will be written down in a separate paper which contains only general theory of matching a coupler with practical hints.

## V. References

- [1] R. Merte, "Technical Realization of W-Band Muffin Tin WBAND-003", Tech. Note 143, ARDB, SLAC, Stanford.