Improved Design of W-Band Muffin Tin WBAND-003

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This paper is part 6 of a group of papers for the first TU-Berlin structure WBAND-003

Abstract

This paper presents the improved design of a 7 cell linear W-Band accelerating structure (Muffin Tin). It is a traveling wave, constant impedance structure with an operating frequency of 91.392 GHz (32 times the SLAC frequency) and is designed for the 2 Pi/3-mode.The structure is planar and should be realized with wire Electro discharge machining (EDM). The general RF parameters, the new design of power input/output coupler as well as the results of a numerical simulation will be shown.

I. Introduction

The first ideas for the design of this structure are written down in [1]. Some improvements, like a new power input/output wave guide with a better transmission behavior and a realizable input/output coupler are done and presented here. This paper is the conclusion of the papers [2-5] and gives you a short overview about this new 91 GHz accelerating structure. It is the second seven cell structure which will be realized. The power couplers are planar and input and output are from both sides, left and right. The inner cavities are optimized for a maximum shunt impedance. Unfortunately, it has a cut coupling iris, so it is a two depth structure. Actually our aim was to design a fully planar one depth structure, but to match a structure with this limitation was more difficult than we thought. A one depth structure is easier to fabricate, especially if EDM or LIGA is the aimed fabrication technology.
The first W-band Muffin Tin (WBAND-000) is presented in [6] and was realized in the spring of 1997. The power input and output of this structure are from the top and the bottom, so it is really built like a sandwich. The coupling cells are matched with a cut iris too. The fabrication technology was wire EDM.

All numerical simulations are done with our improved code GdfidL [7], which is freely available and faster than MAFIA.

II. Geometry

The aimed frequency is 91.392 GHz, this gives a wavelength of l_w = 3.283 mm and a period length for the 2 Pi/3-mode of p = 1.094 mm. The iris thickness was fixed to t = 0.23 mm. The aperture for the beam influences the bandwidth, shunt impedance and wakefields. It is chosen an aperture to wavelength relation of 0.16, which results in an aperture of 2a = 1.05 mm. The width of the cavity is w = 2.363 mm. The depth of the cavity is 2b = 2.54 mm which is the size of the standard WR-10 wave guide and a small advantage because no tapering in this direction is necessary. The length of one cavity in beam direction is g = 0.864 mm. Figure 1 shows one half of the inner structure with 7 cells.

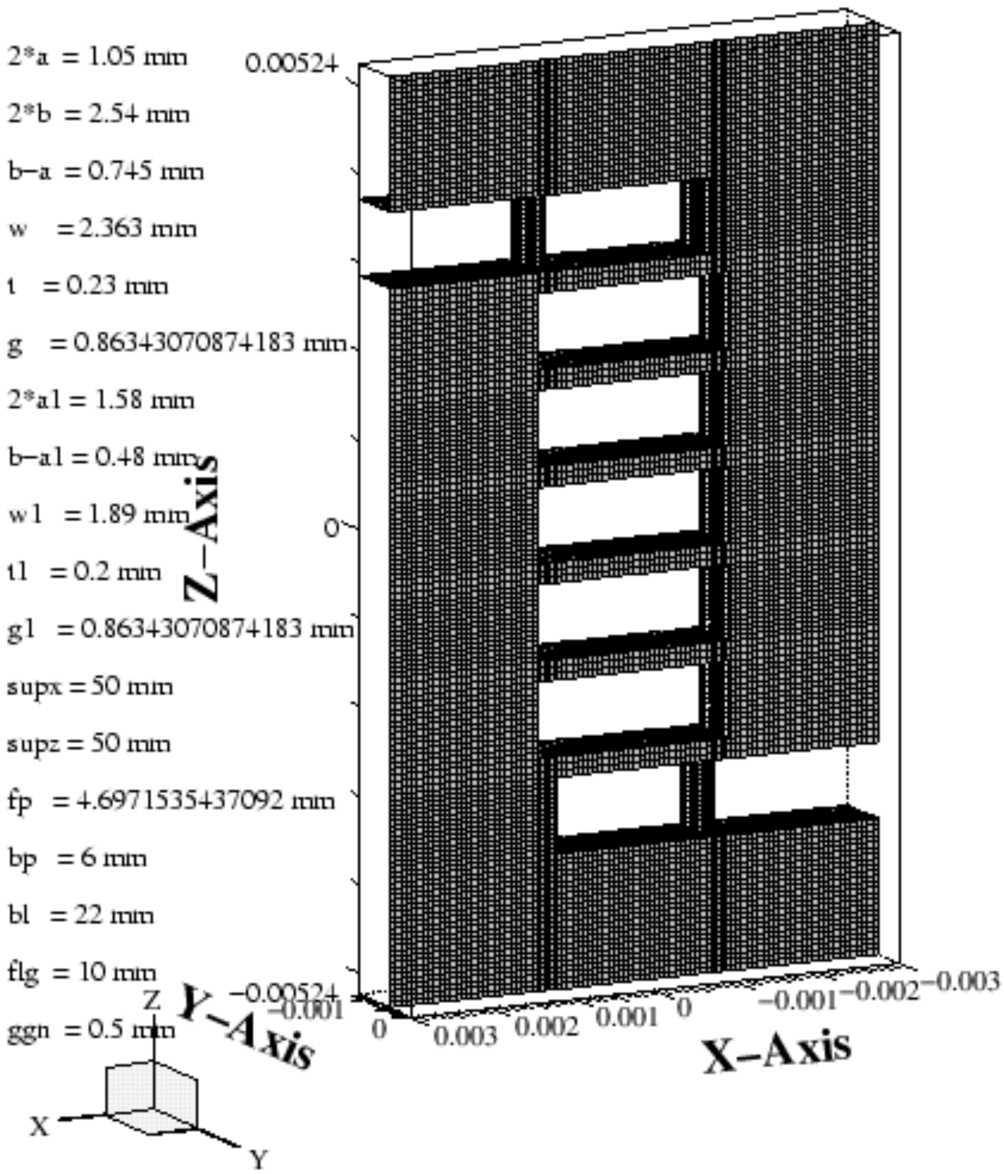

FIGURE 1. GdfidL model of the inner structure.

III. RF Parameters

The operating frequency of this structure is 91.392 GHz (32 times the SLAC frequency). It is a traveling wave constant impedance structure and designed for the 2 Pi/3-mode. The basic RF parameters we found for an optimized shunt impedance are listed in table 1. For the calculation of the maximum length L_{max} of the structure, we used a τ of 0.8 ($\tau = \alpha L$). Using this L_{max} we get a maximal number of accelerating cells on one structure of $N_{max} = 178$.

$$r/Q_0 = 81.6\ \mathrm{k\Omega/m}$$
$$Q_0 = 2490,\ r = 200\ \mathrm{M\Omega/m}$$
$$v_g/c_0 = 9.4\ \%$$
$$\alpha = 4.1\ \mathrm{1/m}$$
$$L_{max} = 19.5\ \mathrm{cm.}$$

TABLE 1. RF parameters of the structure.

IV. Power coupler

To get the power into the structure we had to detour in the input and output wave guide. The flange of the standard WR-10 wave guide which will be mounted on the structure is very large and would overlap with the pumping slots. These pumping slots are needed for an alternative transverse bead pull measurement. So this wave guide was redirected until the pumping slots were free. More details for this are in [2] and [3]. Figure 2 shows the modeled detoured coupler.

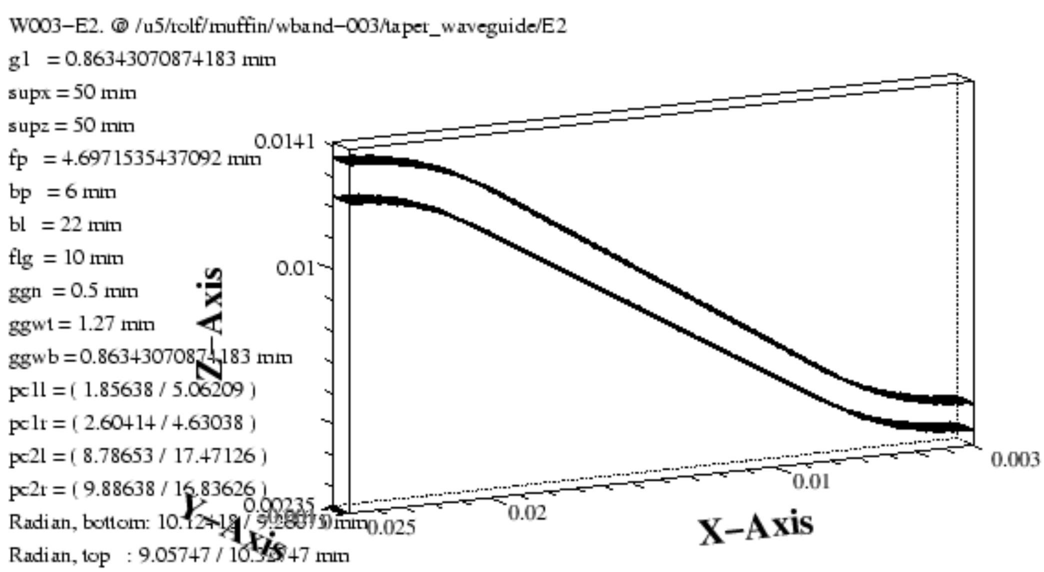

FIGURE 2. GdfidL model of the detoured coupler [2].

V. Coupling cells

A problem was to match this coupler to the structure, because our aim was to create a single depth structure. In the short time it was not possible to find a satisfied solution. So a cut iris was designed. Especially for the aimed fabrication technology we would use, the EDM method, we had to cut this iris diagonally. More detailed information for this are presented in [4]. Figure 3 shows a zoom of a diagonally cut iris.

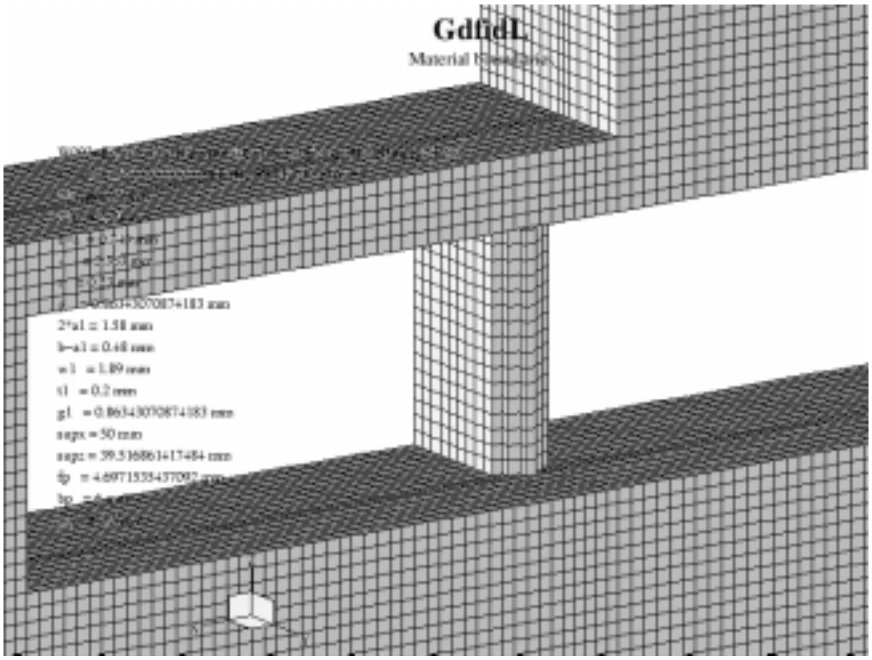

FIGURE 3. GdfidL model of the matched iris and coupling cells [4].

VI. Complete structure

The whole structure is presented in figure 4. You can see the inner cavities, the fiber pipe or pumping slots, the beam pipe and the two detoured input and output power coupler with integrated taper. For more information about the technical realization, see [5].

Figure 5 shows a field plot of the 2 Pi/3 mode at the aimed frequency of 91.392 GHz and in figure 6-7 the S parameter charts of numerical simulation are presented.

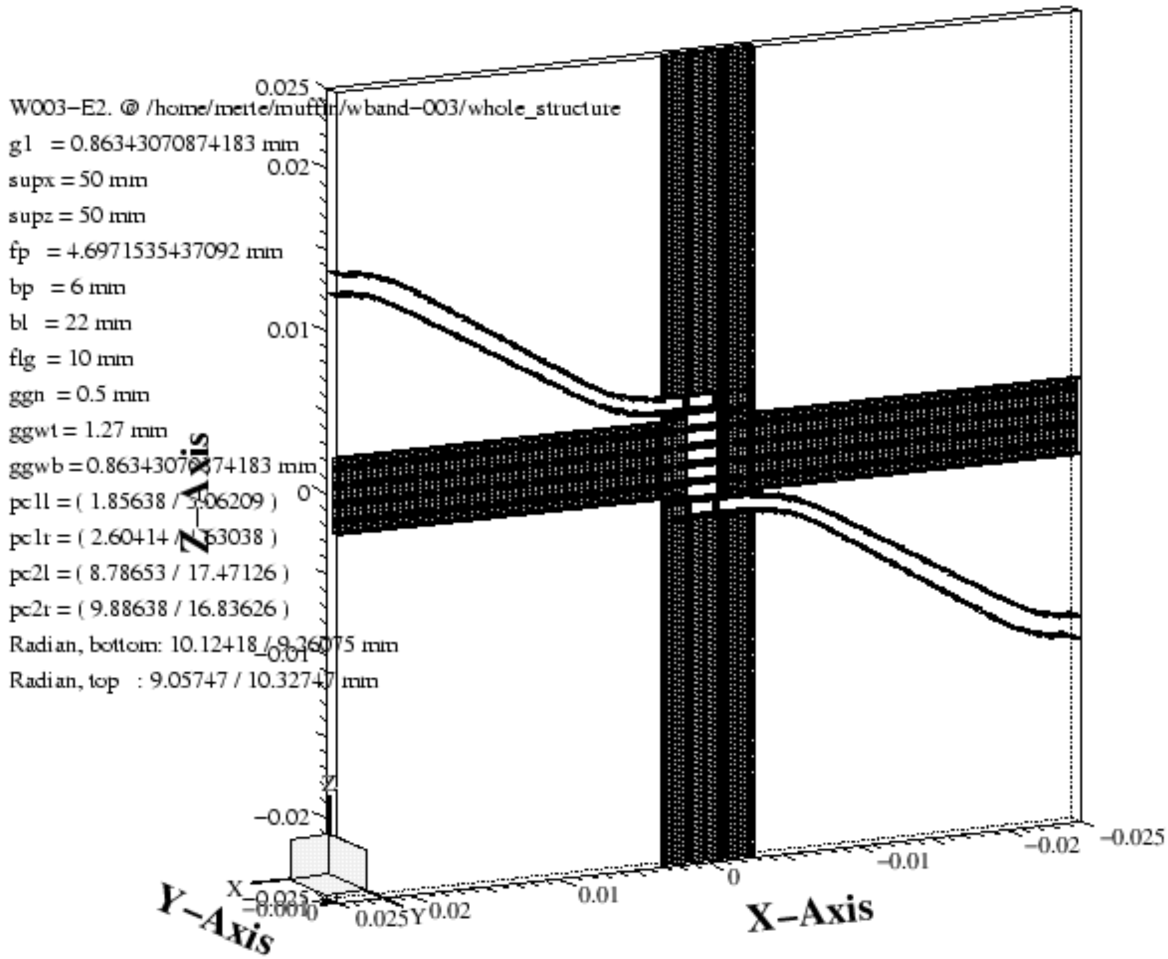

FIGURE 4. GdfidL model of the complete structure [5].

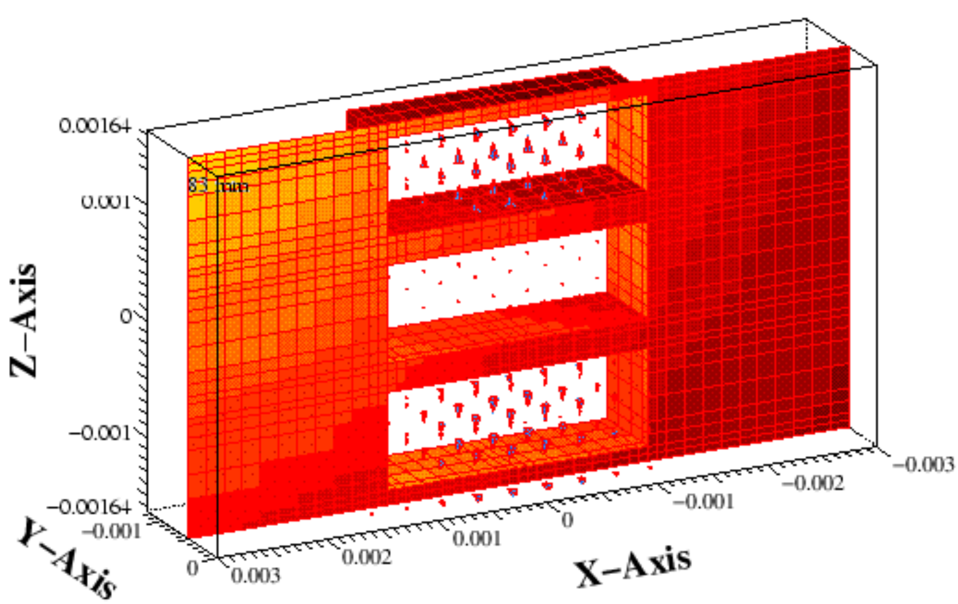

FIGURE 5. Field plot of the 2 Pi/3 mode at 91.392 GHz.

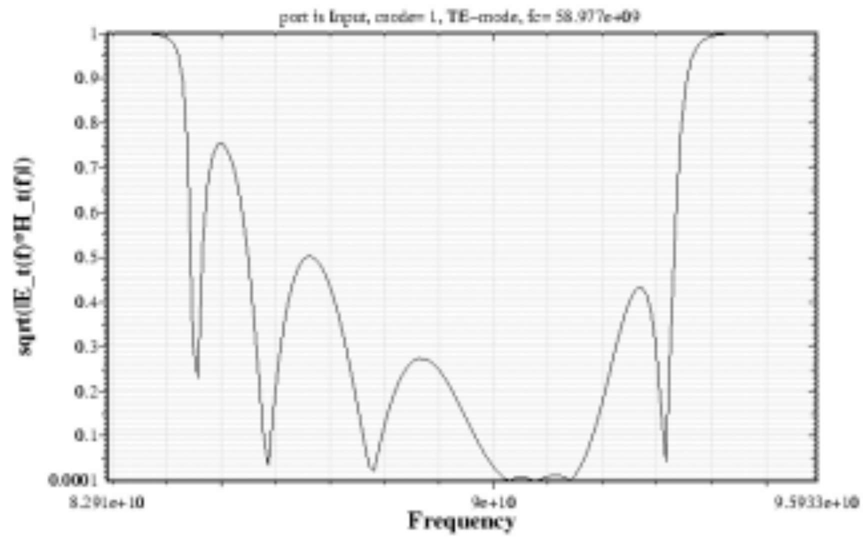

FIGURE 6. S_{11} chart of the diagonally cut iris with N=7 cells.

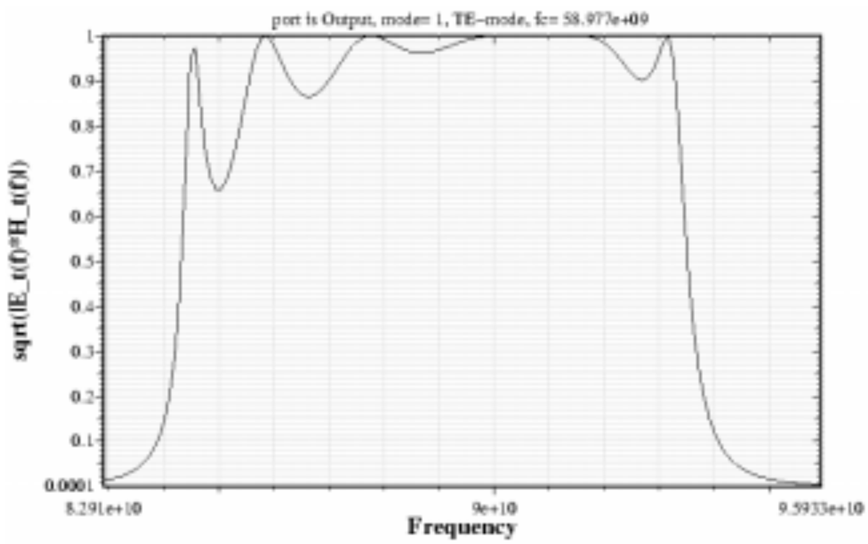

FIGURE 7. S_{12} chart of the diagonally cut iris with N=7 cells.

We all are curios if the measurement is as good as this simulation !

VII. References

[1] R. Merte, “First Design of a W-Band Muffin Tin, Cold Test Model”, TET Note 15/97, Inst. f. Theoretische Elektrotechnik, TU-Berlin.

[2] R. Merte, “Improved Shape of an Input/Output Wave Guide with Integrated Taper for W-Band Muffin Tin WBAND-003”, Tech. Note 140, ARDB, SLAC, Stanford.

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[4] R. Merte, “Matched Input/Output Cavities of W-Band Muffin Tin WBAND-003”, Tech. Note 142, ARDB, SLAC, Stanford.

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[6] P.J. Chou, G.B. Bowden, M.R. Copeland, H. Henke, A. Menegat, D.P. Pritzkau, R.H. Siemann, “DESIGN AND FABRICATION OF A TRAVELING-WAVE MUFFIN-TIN ACCELERATING STRUCTURE AT 90 GHZ”, PAC97, Paper 5B011, SLAC-PUB-7498.

[7] W. Bruns, “GdfidL: A finite difference program for arbitrarily small perturbations in rectangular geometries”, IEEE Trans. Magn. Vol. 32, No. 3 May 1996.