RECTANGULAR WAVEGUIDE COUPLER FOR TWO TESLA SUPERCAVITIES

J.Boster, J.Dicke, M.Dohlus, H.Hartwig, N.Holtkamp,
A.Jöstingmeier, C.Martens
Deutsches Elektronen-Synchrotron DESY
Notkestr.85, 22607 Hamburg, Germany

V.Kaljuzhny, A.Panomarenko, S.Yarigin, A.Zavadtsev,
Moscow State Engineering Physics Institute MEPhI
(Technical University)
Kashirskoe sh. 31, 115409, Moscow, Russia

K.Jin
National Synchrotron Radiation Laboratory NSRL
Univ. of Sci. & Tech. of China
230029 Hefei, Anhui, P.R.China

Abstract

A rectangular waveguide coupler design (RWG coupler) for two M×N-cells TESLA supercavities is described. The geometrical dimensions for different RWG couplers are determined. The electromagnetic field distribution under the beam loading condition is investigated and the transverse kick caused by the RF fields of the RWG coupler is estimated.

I. Introduction

The design of coaxial coupler for 9-cells TESLA cavity operating at π-mode 1.3 GHz frequency is described in [1]. Due to nonsymmetrical design of a coaxial input coupler, a transverse kick caused by electromagnetic fields is inevitable. The fill factor defined as a ratio of active accelerating system length to total accelerating system length is less then 0.75.

To increase the fill factor and to decrease the number of input and HOM couplers an M×N-cells supercavity was suggested in [2]. It consists of M subcavities coupled by $\lambda/2$-length beam pipes. Each subcavity has N cells and field oscillation in the neighbouring cells has π-phase shift. Cell-to-cell coupling coefficient in each subcavity is equal to K_c=0.019. Field oscillation in the neighbouring cells connected by $\lambda/2$-length beam pipe has 0-phase shift. Thus, the supercavity has an operational 0-π-mode and, as consequence, possess some field amplitude stabilization along the cavity [3]. The beam pipes between subcavities have diameter $2R_{bpc}$=114 mm and provide the coupling coefficient K_{s-s}=0.002 between neighbouring cells connected by those beam pipes. A coaxial coupler for two supercavities is considered in [4].

To avoid a transverse kick caused by nonsymmetrical electromagnetic fields a symmetrical coaxial coupler was proposed to drive two supercavities [5]. Therefore this setup has three planes of symmetry. Such couplers require additional $\lambda/2$-length beam pipe due to π phase shift in the oscillation of the fields in the neighbouring cells of the supercavities connected to the coupler. Due to the longitudinal symmetry of this coupler, only monopole modes with the odd symmetry can be stimulated by the coupler. This improves the field nonuniformity. On the other side, all modes with the even symmetry stimulated by the beam cannot couple to the input waveguide. The transient beam loading of one side stimulated 4×7-cells supercavity is investigated in [2,6,8]. An investigation of the double 4×7-cells supercavity stimulation with even or odd symmetry has not yet been done.

We propose to use a rectangular waveguide coupler to drive two supercavities, which further exploits the effective accelerating length of TESLA and has certain other advantages. The transverse kick due to the coupler asymmetry is estimated.

II. Parameters of TESLA cavities

Parameters of the 9-cells TESLA cavity are presented in Table1. These cavity parameters were calculated with formulae (1) and correspond to bunch parameters listed in the same table.

$$
Q_{ext} = \frac{\pi E_{acc\ eff} N_{cell} c}{4K_{loss} N_{be} e f_b}, \tau_{op} = \frac{E_{acc\ eff} N_{cell} c}{4K_{loss} N_{be} e f_b f_{op}}
$$

$$
t_1 = \tau_{op} \ln 2, \qquad P_{gen} = \frac{E_{acc\ eff} N_{cell} c N_{be} e f_b}{2f_{op}} \tag{1}
$$

$$
P_{gen} = \frac{E_{acc\ eff} N_{cell} c N_{be} e f_b}{2f_{op}}, \quad \frac{K_{loss}\left(\frac{V}{pC}\right)}{N_{cell}} = \begin{Bmatrix} 0.2131 & 4 \times 7 \text{ cells} \\ 0.2337 & 9 \text{ cells} \end{Bmatrix}
$$

$$
c = 2.9979245 \times 10^{8} \text{ m/sec}
$$

$$
e = 1.6021892 \times 10^{-19} \text{ C}
$$

USUAL
one 9-cells CAVITY

$E_{acc\ eff}$, V/m	f_{op}, HZ	T_{RF}, sec	N_{cell}
2.500E+7	1.300000000E+9	1.330000000E-3	9
K_{loss}/N_{cell}, V/C	K_{loss}, V/C	f_{op}/f_b	N_{be}
2.35061E+11	2.11555E+12	9.20000E+2	3.63000E+10
τ_{op}, sec	τ_{op}/T_{RF}	f_b, HZ	
7.461067048E-4	5.60982E-1	1.413043478E+6	
Q_{ext}	$Q_{ext\,(1+1)}$	q_b, C	
3.047152345E+6	3.385724828E+5	5.815947E-9	
t_1, sec	t_1/T_{RF}	I_b, A	P_{gen}, W
5.171617588E-4	3.88843E-1	8.218186E-3	2.132091E+5

Table 1
Parameters of the 9-cells TESLA cavity and bunch parameters.

Here: $E_{acc\ eff}$ is an average effective accelerating field gradient in the cavity,
T_{RF} is RF pulse duration,
f_{op} and f_b are operational radio frequency and bunch repetition frequency,
N_{be} is the number of particles in the bunch,
q_b and I_b are bunch charge and pulse beam current,
K_{loss} and K_{loss}/N_{cells} are loss parameter of the cavity and loss parameter per cell,

Q_{ext} and $Q_{ext(1+1)}$ are external Q-factor of the cavity and external Q-factor of the first (input) cell,

τ_{op} is time decay of the operational mode,

t_1 is time moment of the first bunch passage the cavity,

P_{gen} is an input power.

Parameters of 2×4×7-cells and 2×4×9-cells supercavities are summarized in Table 2.

SUPERCAVITY
two 4*7-cells cavities

$E_{acc\ eff}$, V/m	f_{op}, HZ	T_{RF}, sec	N_{cell}
2.500E+7	1.300000000E+9	1.330000000E-3	56
K_{loss}/N_{cell}, V/C	K_{loss}, V/C	f_{op}/f_b	N_{be}
2.13071E+11	1.19320E+13	9.20000E+2	3.63000E+10
τ_{op}, sec	τ_{op}/T_{RF}	f_b, HZ	
8.231068204E-4	6.18877E-1	1.413043478E+6	
Q_{ext}	$Q_{ext\,(1+1)}$	q_b, C	
3.361626242E+6	1.200580801E+5	5.815947E-9	
t_1, sec	t_1/T_{RF}	I_b, A	P_{gen}, W
5.705341719E-4	4.28973E-1	8.218186E-3	1.326635E+6

Table 2a

SUPERCAVITY
two 4*9-cells cavities

$E_{acc\ eff}$, V/m	f_{op}, HZ	T_{RF}, sec	N_{cell}
2.500E+7	1.300000000E+9	1.330000000E-3	72
K_{loss}/N_{cell}, V/C	K_{loss}, V/C	f_{op}/f_b	N_{be}
2.13071E+11	1.53411E+13	9.20000E+2	3.63000E+10
τ_{op}, sec	τ_{op}/T_{RF}	f_b, HZ	
8.231068204E-4	6.18877E-1	1.413043478E+6	
Q_{ext}	$Q_{ext\,(1+1)}$	q_b, C	
3.361626242E+6	9.337850673E+4	5.815947E-9	
t_1, sec	t_1/T_{RF}	I_b, A	P_{gen}, W
5.705341719E-4	4.28973E-1	8.218186E-3	1.705673E+6

Table 2b

Table 2
Parameters of 2×4×7-cells and 2×4×9-cells TESLA supercavities.

Table 2 represents parameters of doubled supercavities. Here $Q_{ext(1+1)}$ is external Q-factor of two neighbouring cells connected to the coupler. Of course the input power must be increased proportionally to the total number of cells in the cavity N_{cells}. It may add multipacting and breakdown problems in increasing the number of cells in the supercavities.

III. Rectangular waveguide coupler for two 4×7-cells TESLA supercavities

The schematic design of a RWG coupler for a double M×N-cells TESLA cavities is shown in Fig.1.

The RWG coupler consists of a 165.1×30 mm^2 rectangular waveguide short-circuited at the one end and coupled with two M×N-cells TESLA supercavities by beam pipes ($2R_{bp}$=78 mm). The position of the short circuiting plane surface L_{short} is chosen to provide $Q_{ext}=3.361626\times10^6$ ($Q_{ext(1+1)}$=120058) for 4×7-cells TESLA cavities (see Table 2). To calculate the $Q_{ext(1+1)}$ dependence on short circuiting plane surface position L_{short} we use MAFIA CODE and slightly modified Kroll-Yu-method [7]. This method permits us to calculate Q_{ext} and a reference plane position in the input part of RWG where the steady state reflection coefficient is equal to +1. To simplify MAFIA calculation we use a half of RWG (15-mm height) and only one cell in our calculation. Table 3 and Fig.2 show $Q_{ext(1+1)}$ and reference plane position dependence on the short circuiting plane surface position L_{short} measured from the cavity axes.

One can see that $Q_{ext(1+1)}$=120000 corresponds to L_{short}=139 mm. It means that length of the short-circuited part of the rectangular waveguide is close to $\Lambda/2\approx161.1$ mm and we can expect high electric field strength in this part of the RWG. Moreover, $Q_{ext(1+1)}$ dependence on short-circuiting plane position has high sensitivity to L_{short} ($dQ_{ext(1+1)}/dL_{short}$ is very large).

To avoid an overvoltage in the short-circuited part of the rectangular waveguide we considered the other form of the short-circuiting surface shown in Fig.3.

In this design short-circuiting surface consists of cylindrical surface with fixed radius R_{sh}=49 mm and two plane surfaces tangential to the cylindrical one. Changing angle α we can obtain the necessary value of Q_{ext}.

Table 4 and Fig.4 show $Q_{ext}(1+1)$ and reference plane position dependence on angle α calculated with Kroll-Yu-method and MAFIA CODE.

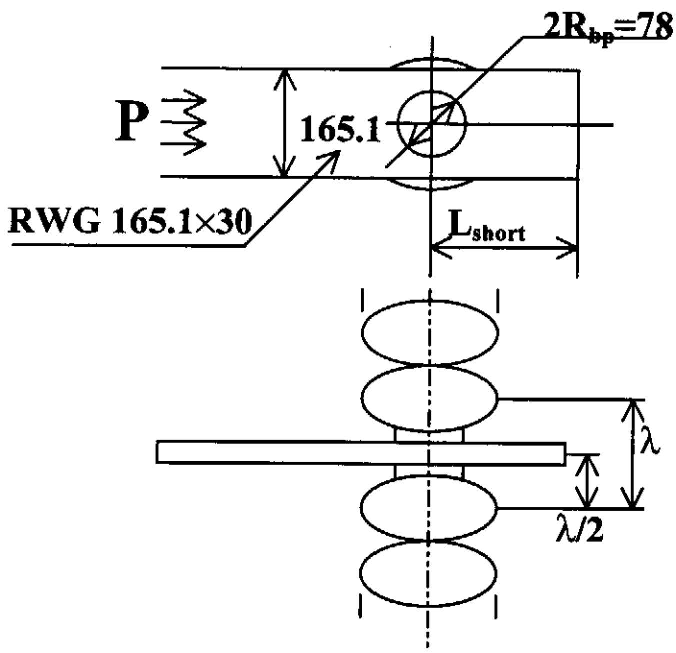


Fig.1. RWG coupler for two M×N-cells TESLA supercavity with the short-circuiting plane surface.

RWG >>>>> 165 * 30 mm for 2 cells
Plane short circuiting surface Rinp.bunch pipe = 39 mm

A_{RWG}, mm: 165.100

Q_{ext}	Ref.Plane, mm	L_{short}, mm	$\sigma_{\Delta Q/Q}$	f_{cell}, Hz	$\sigma_{\Delta f/f}$
7.23031690E+4	126.837	40.552	1.658E-2	1.281148222E+9	8.588E-7
6.07331869E+4	124.066	50.552	8.824E-3	1.281147068E+9	8.462E-7
5.05617940E+4	120.992	60.552	3.235E-2	1.281146281E+9	2.410E-6
4.27214320E+4	117.604	70.552	1.818E-2	1.281145659E+9	2.453E-6
3.60626500E+4	113.261	80.552	1.086E-1	1.281143305E+9	8.273E-6
2.97435630E+4	107.426	90.552	8.395E-2	1.281147570E+9	9.549E-6
2.20994590E+4	99.430	100.552	3.167E-1	1.281135852E+9	1.163E-4
1.81079090E+4	86.739	110.552	9.309E-2	1.281153305E+9	1.921E-5
1.80980250E+4	61.879	120.552	1.502E-1	1.281171807E+9	2.191E-5
2.02017890E+4	210.890	125.552	1.121E-1	1.281183319E+9	2.097E-5
3.18095640E+4	194.087	130.552	6.901E-2	1.281185599E+9	9.126E-6
4.84301230E+4	184.983	133.552	1.048E-1	1.281184567E+9	1.147E-5
7.76177360E+4	177.087	136.552	6.332E-2	1.281181682E+9	4.081E-6
1.19062790E+5	171.890	138.842	1.554E-2	1.281178773E+9	5.580E-7
1.72271832E+5	168.415	140.552	1.101E-2	1.281176698E+9	2.640E-7
3.75693570E+5	163.145	143.552	4.105E-2	1.281173230E+9	9.755E-7

Table 3

$Q_{ext(1+1)}$ and reference plane position dependence on the short-circuiting plane surface position

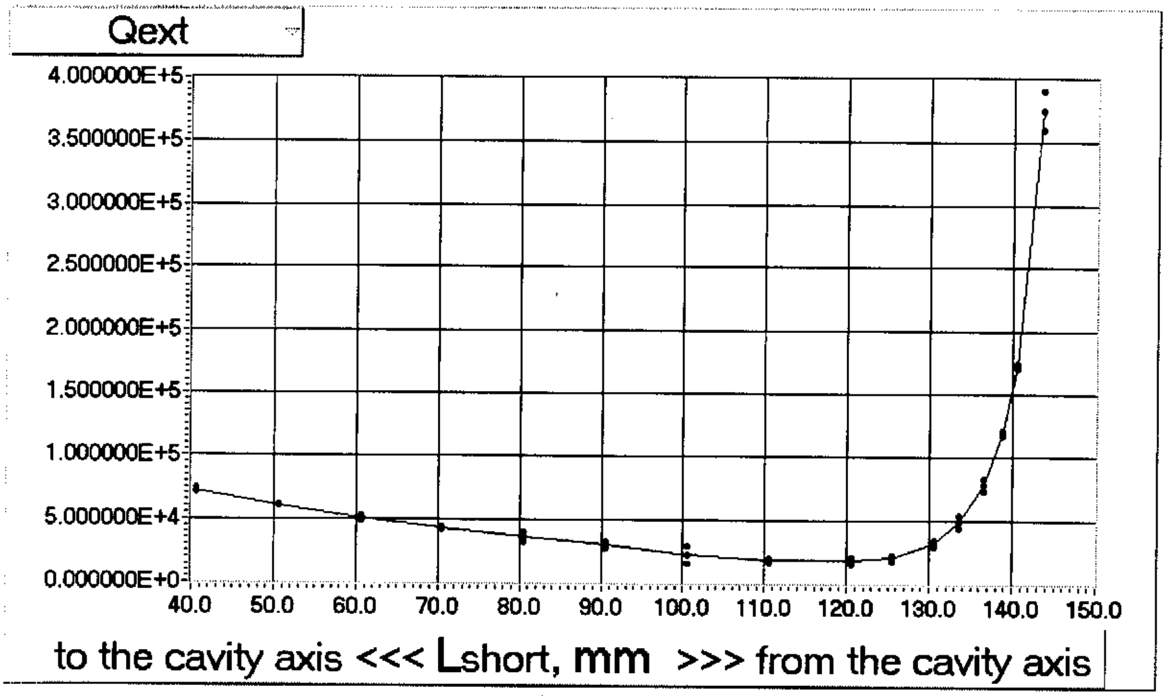


Fig.2a

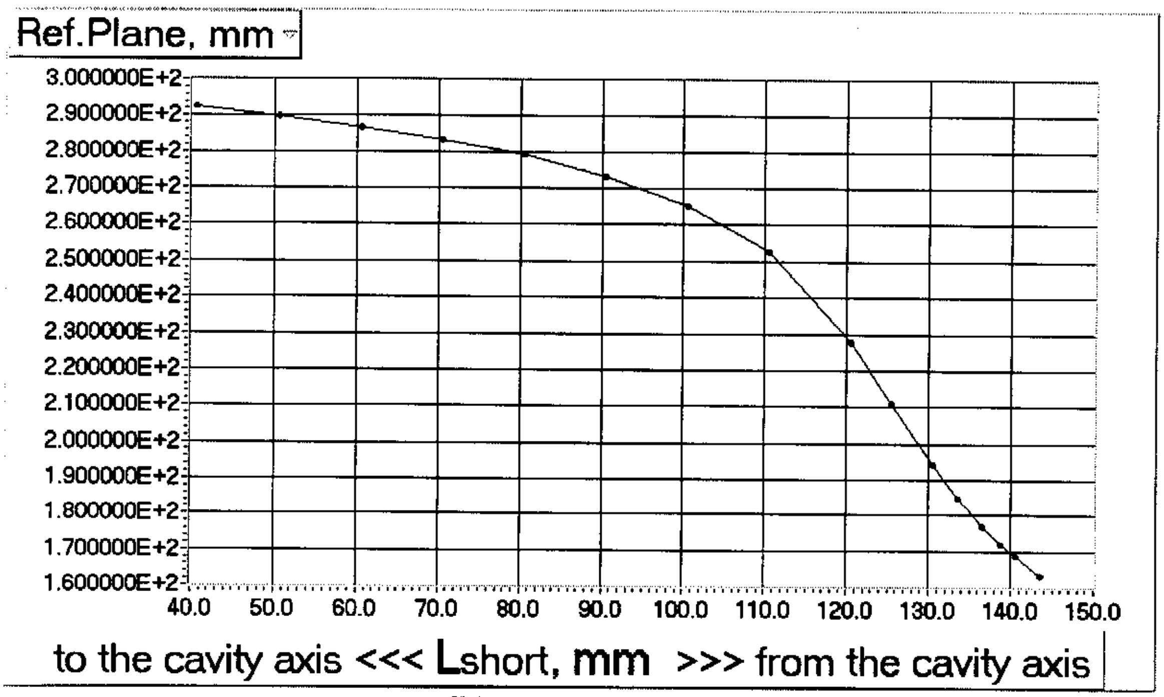


Fig.2b

Fig.2. $Q_{ext(1+1)}$ and reference plane position dependence on the short-circuiting plane surface position

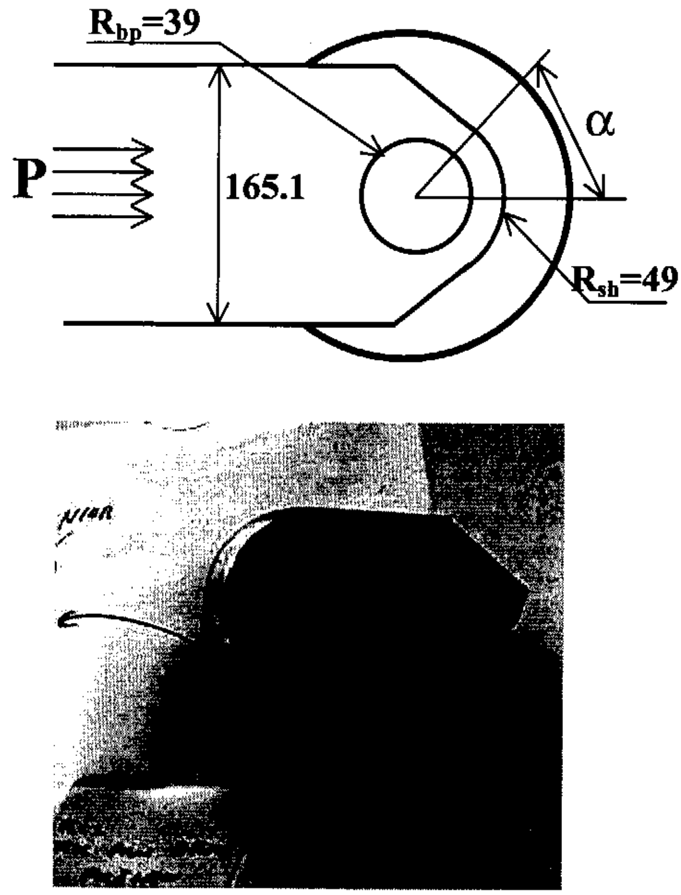


Fig.3. RWG coupler for two M×N-cells TESLA supercavity

RWG >>>>> 165.1 * 30 mm for 2 cells
Cylindrical(R=49 mm)+plane short circuiting surface (α=var)
Rbunch pipe = 39 mm

A_{RWG}, mm: 165.100

Q_{ext}	Ref.Plane, mm	α*π then degrees	$\sigma_{\Delta Q/Q}$	f_{cel}, Hz	$\sigma_{\Delta f/f}$
7.30602266E+4	127.635	18.000	1.203E-3	1.281147842E+9	6.217E-8
8.65765876E+4	131.796	36.000	1.622E-3	1.281148046E+9	8.505E-8
1.11146356E+5	140.023	54.000	3.506E-3	1.281147824E+9	1.705E-7
1.21733295E+5	143.741	58.500	5.706E-4	1.281147681E+9	1.891E-8
1.37623220E+5	148.966	63.000	1.464E-3	1.281147477E+9	5.868E-8
		144.000			
		108.000			
		72.000			
		63.000			
		54.000			

Table 4

$Q_{ext\,(1+1)}$ and reference plane position dependence on α

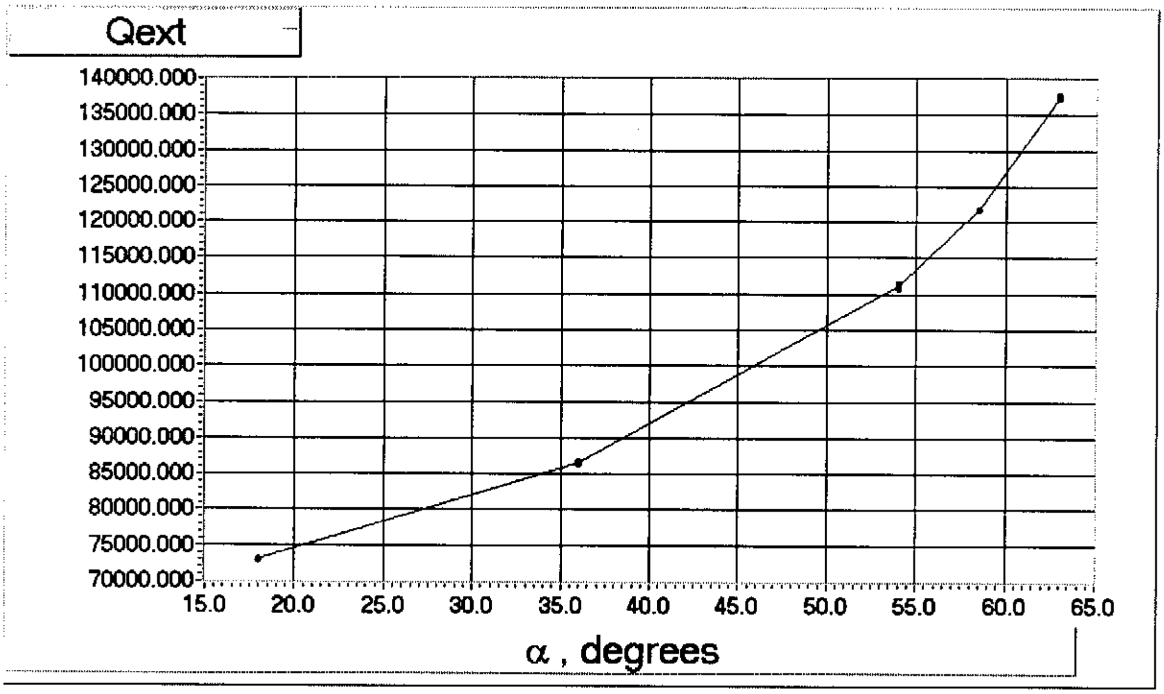


Fig.4a

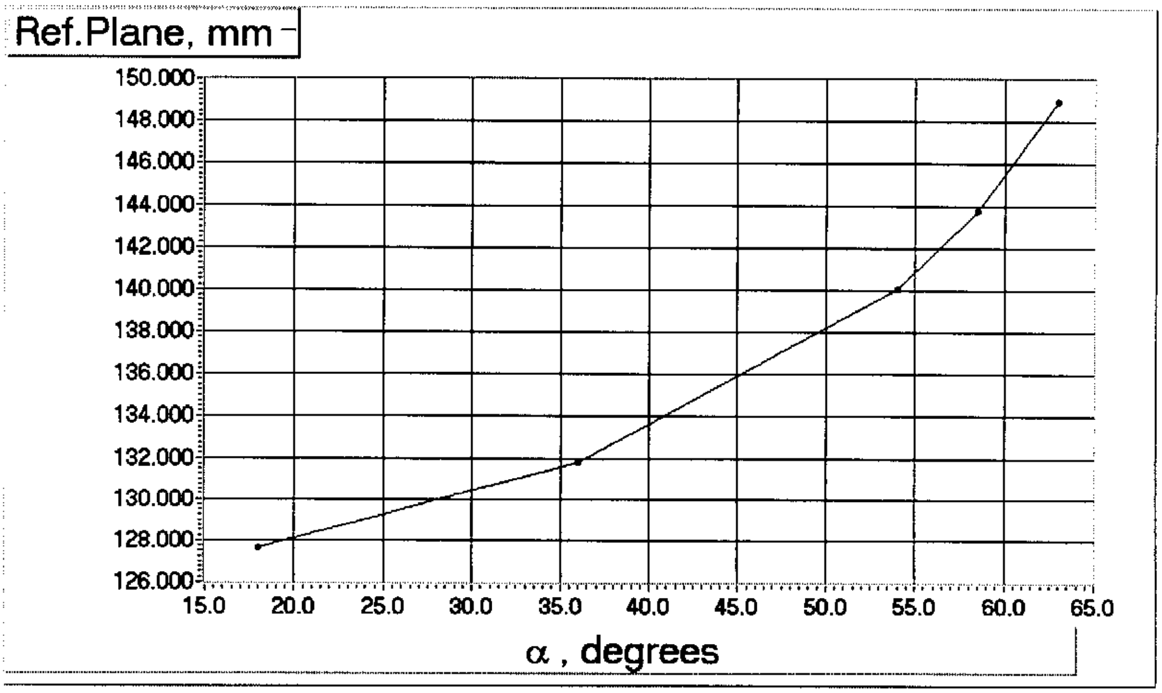


Fig.6b

Fig.4. $Q_{ext\,(1+1)}$ and reference plane position dependence on α

From these data one can obtain angle α_{op}=58.5° and $Q_{ext(1+1)}$=121733 (angle between plane surfaces is equal to β_{op}=63°).

Such short-circuiting surface provides the necessary value of $Q_{ext\ (1+1)}$ and low level of the electric field strength in the rectangular waveguide. Due to 0-phase shift in the field oscillation of the neighbouring cells coupled with the RWG there is no additional $\lambda/2$-length beam pipe as in the case of symmetrical coaxial coupler.

IV. Electromagnetic field distribution in the RWG coupler and the first cell

The first bunch passes the cavity at the time moment t_1=570.534 μs corresponding to zero input reflection coefficient (see Table 2a). After this time moment input reflection coefficient is very close to zero under the beam loading condition for a given input power P=1.327 MW, bunch parameters q_b=5.815 nC, f_b=1.413 MHz and cavity parameters $Q_{ext}=3.362\times10^6$, $K_{loss}/N_{cell}=2.13071\times10^{11}$ V/C ($E_{acc\ eff}=25\times10^6$ V/m).

To study a field distribution along the beam line we calculate the field distribution under the travelling wave regime in the beginning part of the input RWG. The geometry used for the field distribution simulation is shown in Fig.5. We use half RWG and one cell. The plane y=0 is a symmetry plane of the investigated system and there are no E_y and B_x field components in this plane.

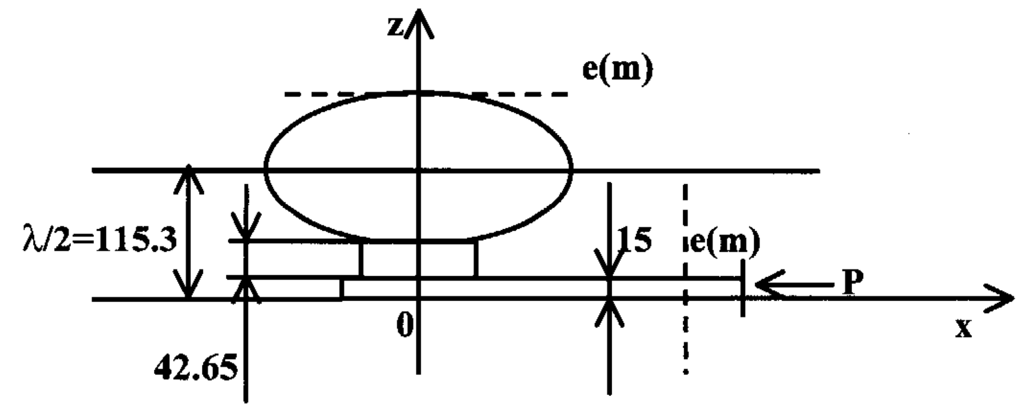


Fig.5. One cell geometry used for the simulation of the field distribution in the RWG coupler and cavity

We use two planes with e-e (electric-electric) or m-m (magnetic-magnetic) boundary conditions in our calculation to simulate travelling wave regime in the input RWG. We choose a position of the plane in the input RWG in such way to obtain the same frequency for both e-e and m-m boundary conditions $f_{e\text{-}e}=f_{m\text{-}m}=f_{op}=1.3$ GHz. The proper linear combination of the two electromagnetic fields permits us to simulate travelling wave condition in the input RWG and correspondingly field amplitude and phase distribution along the beam line (z-axis) and x-axis. Three field components E_z, E_x and cB_y (here c is velocity of light) are of great interest ($E_y=cB_x=0$ in the y=0 plane).

Fig.6 and Fig.7 show the amplitude and phase distribution along x-axis for E_z and cB_y components at z=1.5 mm and y=0. Here and later field components correspond to the input power P=1.327 MW. One can see that there is travelling wave in the beginning part of the input RWG (linear dependence of the phase on x-coordinate and constant amplitude) and standing wave regime in the vicinity of the beam pipe ($R_{b.p.}=39$ mm). The amplitude of E_z-component in the beginning part of the input RWG is equal to 7.509×10^5 V/m and increases up to 2.077×10^6 V/m on the beam line in the middle plane of the RWG. The coordinates x=±39 mm correspond to the beam pipe radius. The amplitude of the cB_y-component is equal to 1.446×10^5 V/m on the beam line at z=1.5 mm and $cB_y=5.374\times10^5$ V/m in the beginning part of the input RWG. Both E_z and cB_y components in the beginning part of the input RWG correspond to the power P=1.327 MW of the travelling wave in the RWG with cross section 165.1×30 mm^2. The E_z-component increases only in the beam pipe region and is not too large out off this region. Thus there is no overvoltage in the RWG and electromagnetic field has a good symmetry.

Fig.8, Fig.9, Fig.10 show the amplitude and phase distribution along z-axis for the E_z, cB_y and E_x components. One can see that $E_{z\ max}=49$ MV/m on the cavity axis at z=115.3 mm (in the middle plane of the cavity cell), cB_y and Ex components have not too large values on the z-axis ($cB_{y\ max}/E_{z\ max}$ = 0.00295, $E_{x\ max}/E_{z\ max}=0.000251$ and $cB_{y\ max}/E_{x\ max}=11.78$).

The cB_y and E_x components strongly decrease in the RWG region and are negligible in the beam pipe and in the first cell of the cavity (see Fig.9 and Fig.10).

Now we have all the necessary data to estimate the transverse kick caused by electromagnetic fields in the RWG coupler.

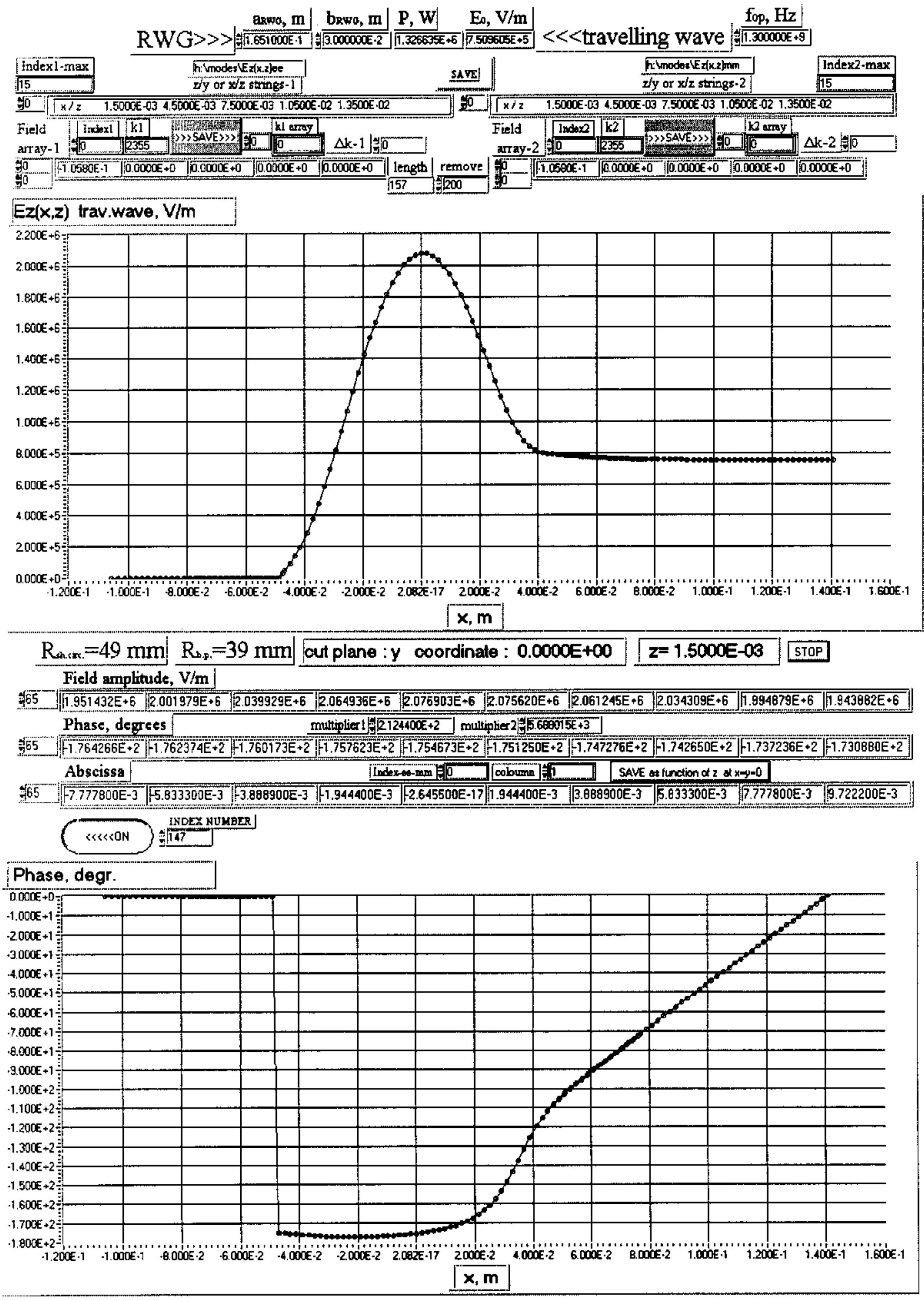


Fig.6. E_z amplitude and phase distribution along x-axis (y=0 and z=1.5 mm)

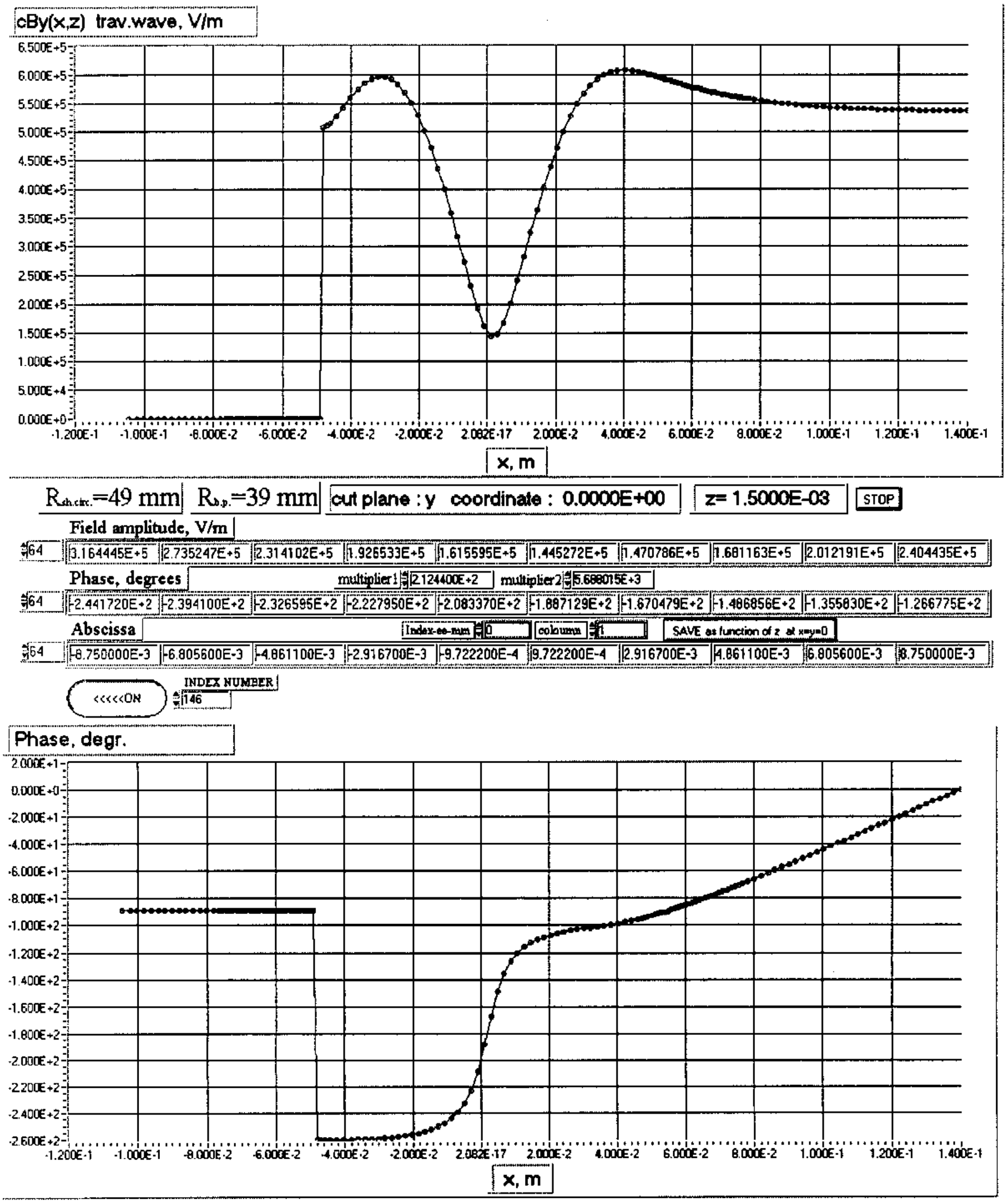


Fig.7. cB_y amplitude and phase distribution along x-axis (y=0 and z=1.5 mm)

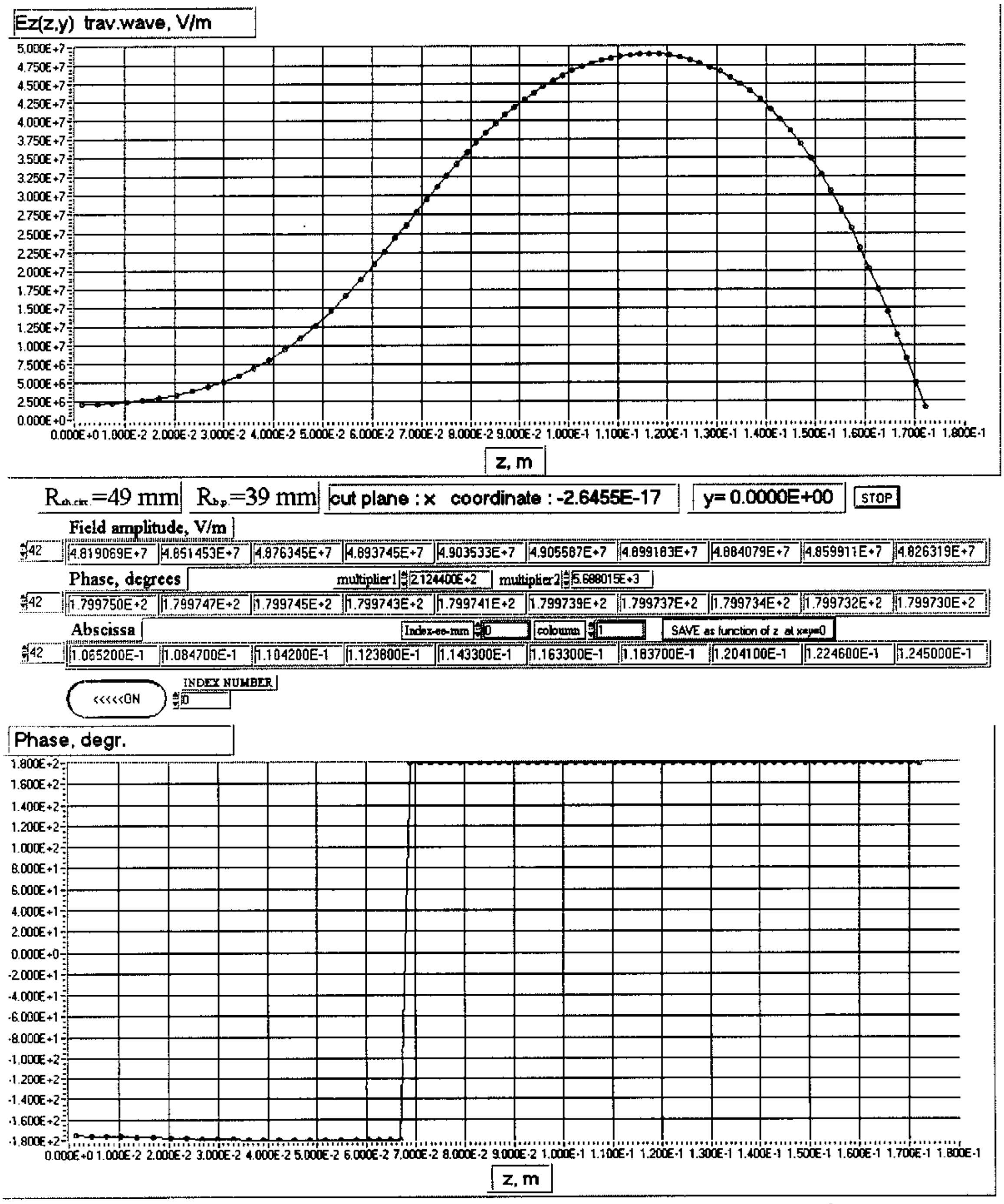
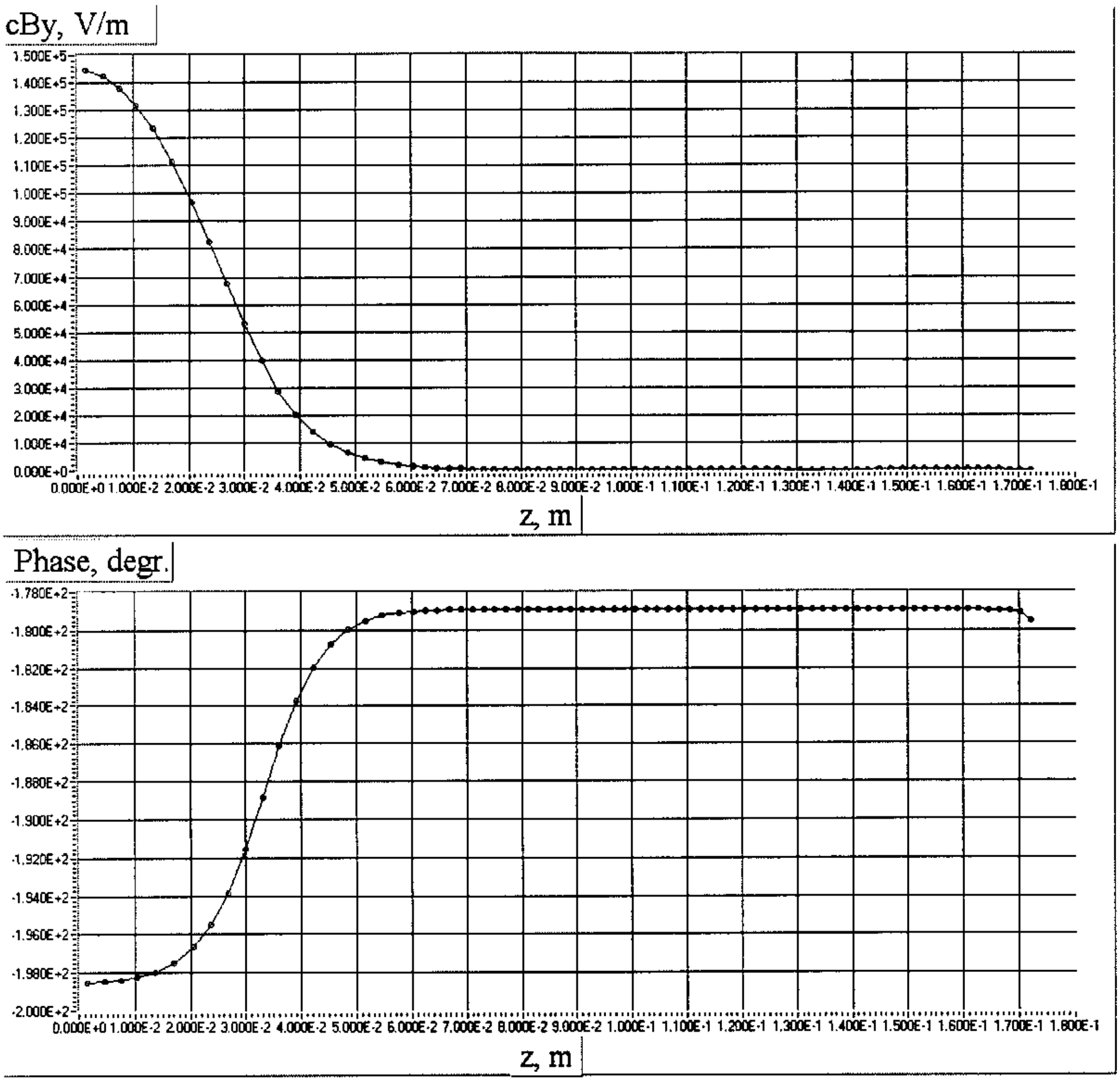
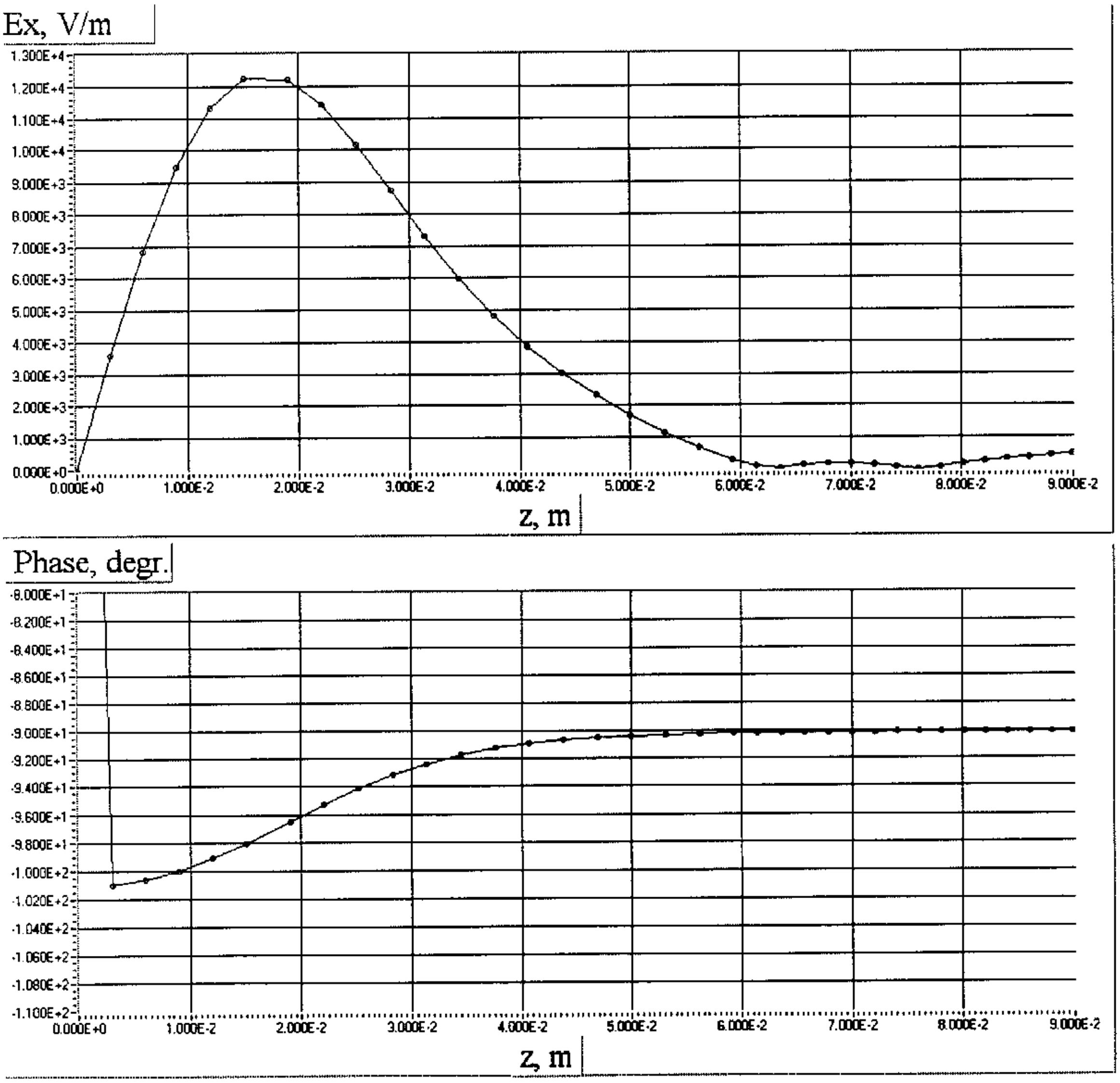


Fig.8. E_z amplitude and phase distribution along z-axis (x=y=0)



cBy, V/m										
0	1.446321E+5	1.424481E+5	1.381168E+5	1.317090E+5	1.233204E+5	1.113443E+5	9.666664E+4	8.250810E+4	6.768995E+4	5.314662E+4
Phase, degrees										
0	-1.985250E+2	-1.984834E+2	-1.983923E+2	-1.982339E+2	-1.979770E+2	-1.974941E+2	-1.966496E+2	-1.954982E+2	-1.938187E+2	-1.915588E+2
Z, m										
0	1.500000E-3	4.500000E-3	7.500000E-3	1.050000E-2	1.350000E-2	1.700000E-2	2.055000E-2	2.365100E-2	2.675100E-2	2.985100E-2

Fig.9. cB_y amplitude and phase distribution along z-axis (x=y=0)



E_x, V/m										
0	0.000000E+0	3.585290E+3	6.841624E+3	9.482926E+3	1.131415E+4	1.225408E+4	1.222547E+4	1.140899E+4	1.016541E+4	8.738460E+3
Phase, degrees										
0	0.000000E+0	-1.010136E+2	-1.006297E+2	-9.999649E+1	-9.913902E+1	-9.809540E+1	-9.653922E+1	-9.530869E+1	-9.416191E+1	-9.316579E+1
Z, m										
0	0.000000E+0	3.000000E-3	6.000000E-3	9.000000E-3	1.200000E-2	1.500000E-2	1.900000E-2	2.210000E-2	2.520100E-2	2.830100E-2

Fig.10. E_x amplitude and phase distribution along z-axis (x=y=0)

V. Estimation of RF kicks through the RWG coupler and two 4×7-cells supercavities

First of all let us estimate RF transverse kick through the RWG coupler caused by the E_x and cB_y components on the beam line. There are only these two components creating x-component of the kick in the plane y=0.

$$\Delta P_x = \frac{q}{c}\int_{-L}^{+L}\left\{E_x(0,0,z) - j\frac{\lambda}{2\pi}\left(\frac{\partial E_x(0,0,z)}{\partial z} - \frac{\partial E_z(0,0,z)}{\partial x}\right)\right\} e^{j\frac{2\pi}{\lambda}z} dz \qquad (2)$$

where E_x and E_z are complex quantities characterized by an amplitudes (real positive value) and phases,

q is a charge of the test particle,

c is light velocity,

$L = 3\lambda/4$,

j is imaginary unit.

In our estimation we can suppose $E_x(0,0,\pm L)=0$ (see Fig.10) and expression (2) takes the following form

$$\Delta P_x = \frac{q}{c} j \frac{\lambda}{2\pi}\int_{-L}^{+L}\frac{\partial E_z(0,0,\ z)}{\partial x} e^{j\frac{2\pi}{\lambda}z} dz$$

Here $E_z(x,\ y,\ z) = E_{z0}(x,\ y,\ z)e^{j\varphi(x,y,z)}$ (3)

$E_{z0}(x,\ y,\ z)$ is an amplitude and

$\varphi(x,\ y,\ z)$ is a phase of z - component of the electric field

Fig.8 shows $E_{z0}(0,0,z)$ and $\varphi(0,0,z)$ distribution along the z-axis. Using last expression one can obtain

$$\Delta P_x = \frac{q}{c}\frac{\lambda}{2\pi}\int_{-L}^{+L}\left\{\frac{\partial E_{z0}(0,0,\ z)}{\partial x} + jE_{z0}(0,0,\ z)\frac{\partial \varphi(0,0,\ z)}{\partial x}\right\} e^{j(\frac{2\pi}{\lambda}z+\varphi(0,0,z)+\frac{\pi}{2})} dz \qquad (4)$$

Fig.11 shows absolute value and phase of the quantity
$j(\lambda/2\pi)\times[\partial E_z(0,0,z)/\partial x]$ as function of z.

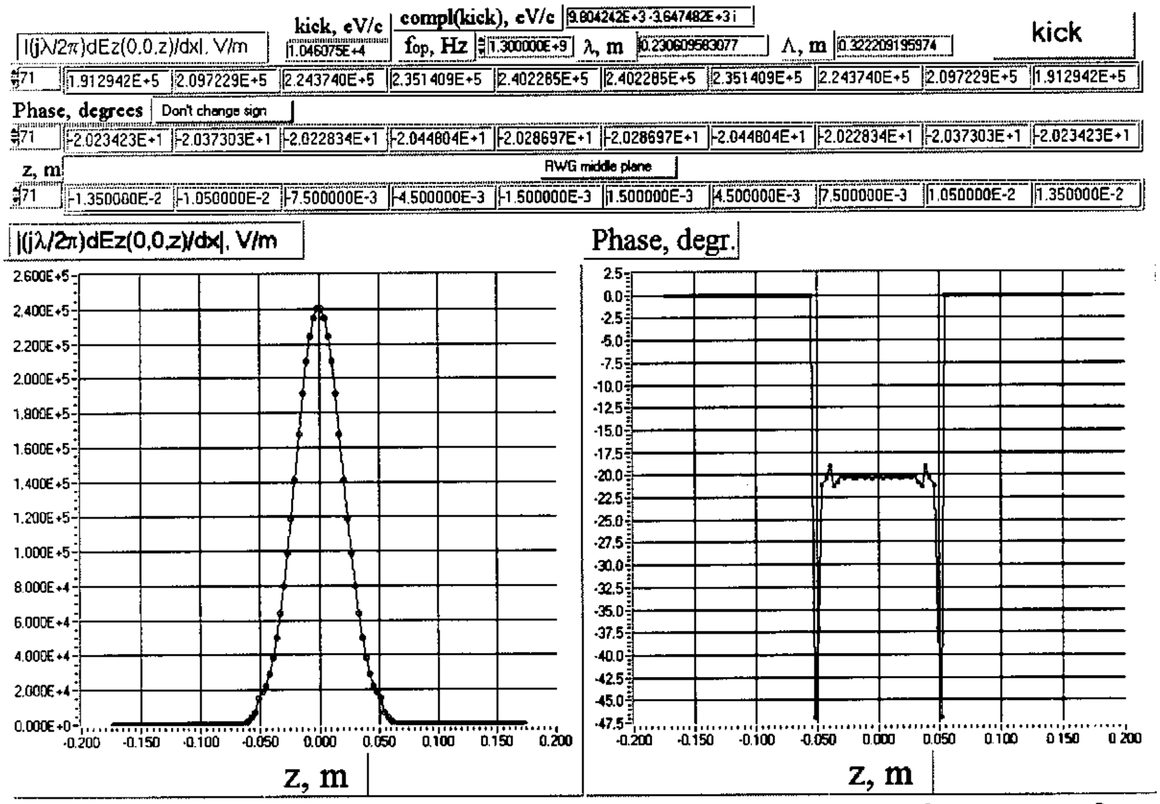


Fig.11.Absolute value and phase of the quantity $j(\lambda/2\pi)\times[\partial E_z(0,0,z)/\partial x]$ as function of z.

Estimated transverse kick is equal to 9.804×10^3 -j3.647 eV/c. At the same time the longitudinal kick in our case is equal to 1.6142×10^8 eV/c. Thus $Re(\Delta P_x)/\Delta P_z=6.074\times10^{-5}$ (56 cells cavity).

The next figures show E_z amplitude and phase distribution along x-axis for different values of z-coordinate:

z=10.5 mm corresponds to RWG region,

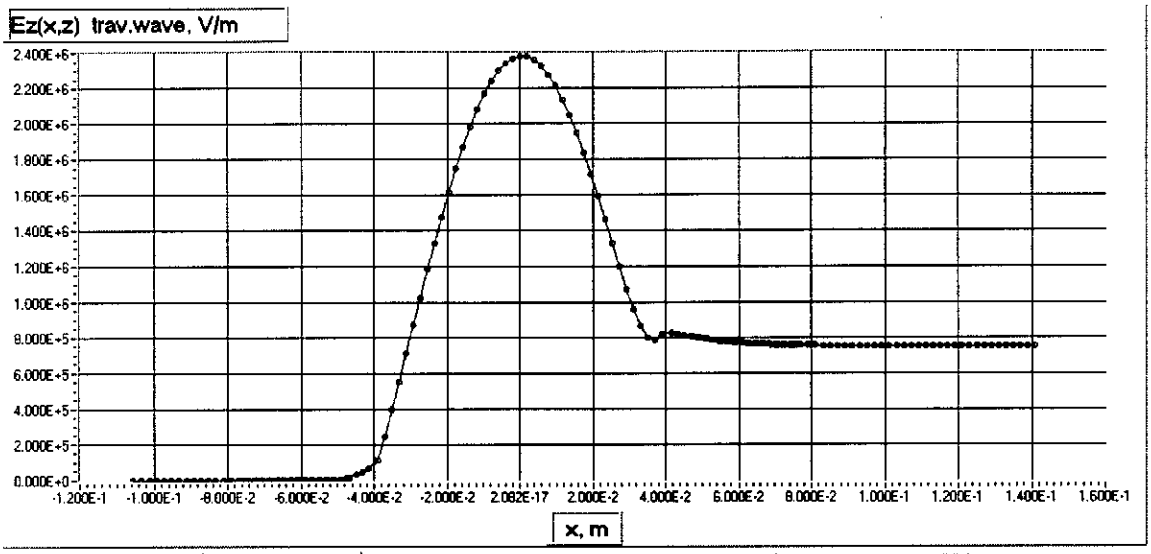
z=17 mm corresponds to the beginning part of the beam pipe,

z=54.7 mm corresponds to the end of the beam pipe,

z=114.3 mm corresponds to the middle region of the cell.

In all cases y=0 (the symmetry plane of the investigated system). The points with E_z=0 and phase=0 lie out off the studied system.

One can see that E_z-component has good amplitude and phase symmetry at z>54.7 mm (end of the beam pipe).



$R_{ch.circ.}$=49 mm $R_{b.p.}$=39 mm cut plane ; y coordinate : 0.0000E+00 z= 1.0500E-02 1.0500E-02

Field amplitude, V/m STOP

65	2.239719E+6	2.297732E+6	2.340822E+6	2.368638E+6	2.380954E+6	2.377669E+6	2.358805E+6	2.324756E+6	2.275924E+6	2.212965E+6

Phase, degrees multiplier1 2.124400E+2 multiplier2 5.688015E+3

65	-1.771350E+2	-1.769884E+2	-1.768183E+2	-1.766219E+2	-1.763953E+2	-1.761333E+2	-1.758299E+2	-1.754774E+2	-1.750662E+2	-1.745840E+2

Abscissa Index-ee-mm 0 coloumn 4 SAVE as function of z at x=y=0

65	-7.777800E-3	-5.833300E-3	-3.888900E-3	-1.944400E-3	-2.645500E-17	1.944400E-3	3.888900E-3	5.833300E-3	7.777800E-3	9.722200E-3

For dEz(0,0,z)/dx calculation>>>>>kick

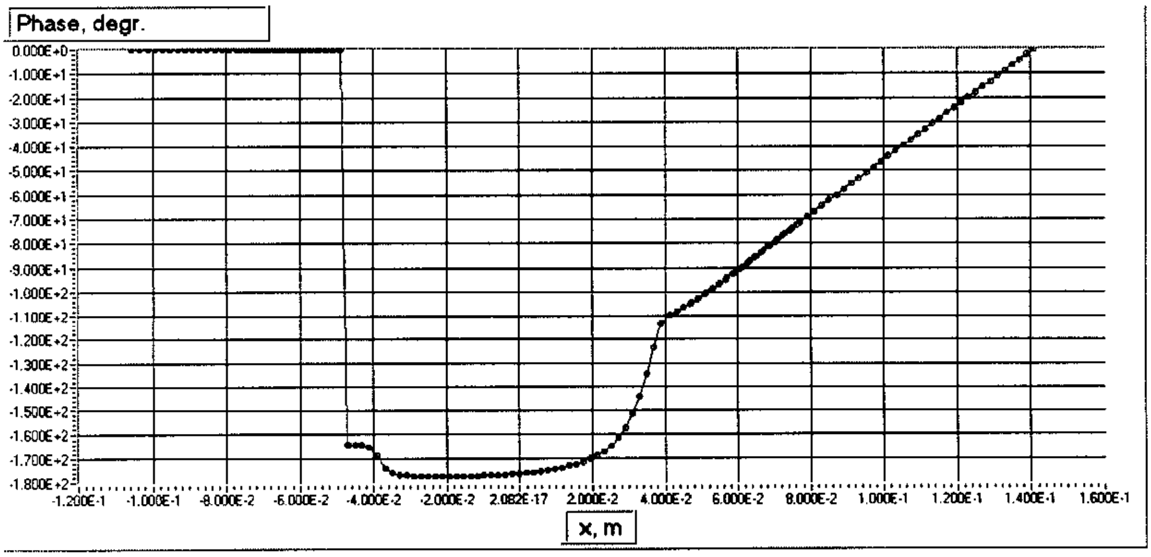
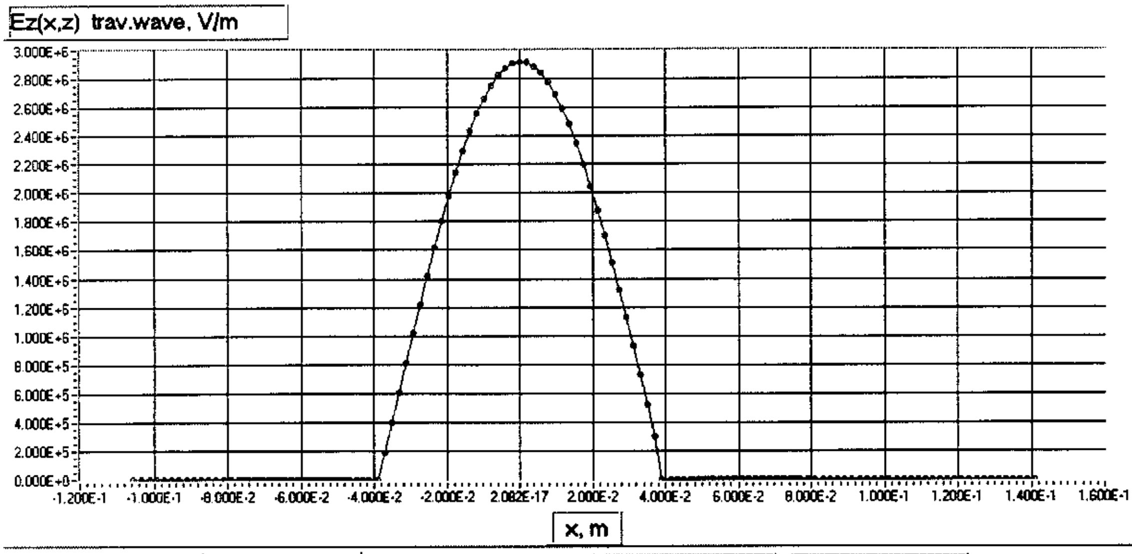


Fig.12a z=10.5 mm



$R_{sh.circ.}$=49 mm | $R_{b.p.}$=39 mm | cut plane : y coordinate : 0.0000E+00 | z= 1.7000E-02 | 1.7000E-02

STOP

Field amplitude, V/m

Phase, degrees   multiplier1 2.124400E+2   multiplier2 5.688015E+3

Abscissa   Index-ee-mm 1   colomn 1   SAVE as function of z at x=y=0

65	2.751007E+6	2.821677E+6	2.873529E+6	2.906206E+6	2.919352E+6	2.913097E+6	2.887210E+6	2.842186E+6	2.778403E+6	2.696366E+6
65	-1.779611E+2	-1.778620E+2	-1.777480E+2	-1.776175E+2	-1.774681E+2	-1.772970E+2	-1.771006E+2	-1.768749E+2	-1.766141E+2	-1.763113E+2
65	-7.777800E-3	-5.833300E-3	-3.888900E-3	-1.944400E-3	-2.645500E-17	1.944400E-3	3.888900E-3	5.833300E-3	7.777800E-3	9.722200E-3

For dEz(0,0,z)/dx calculation>>>>>kick

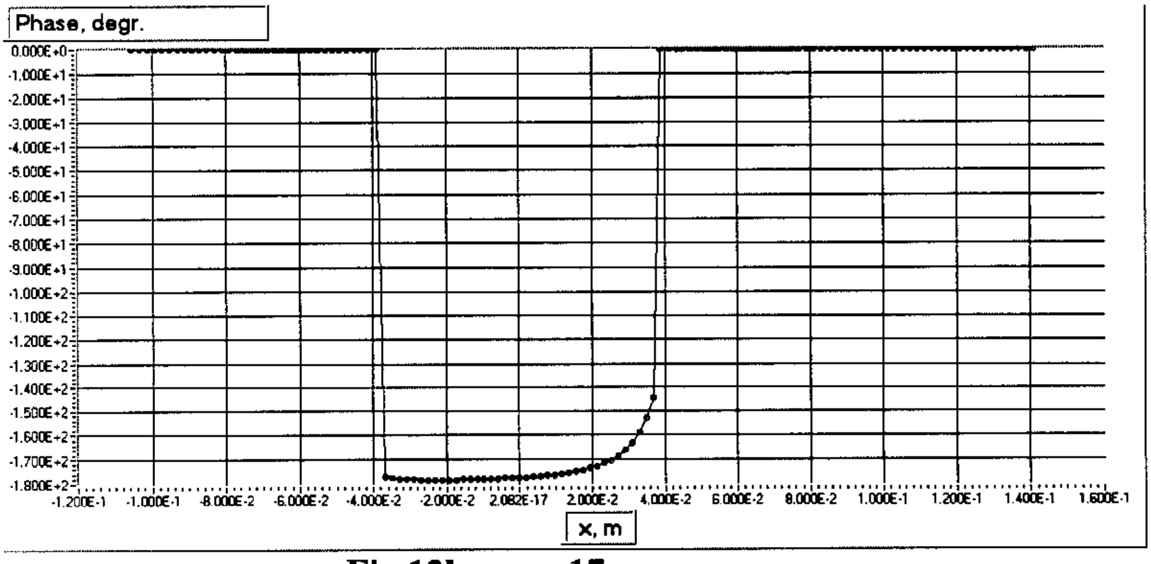


Fig.12b z=17 mm

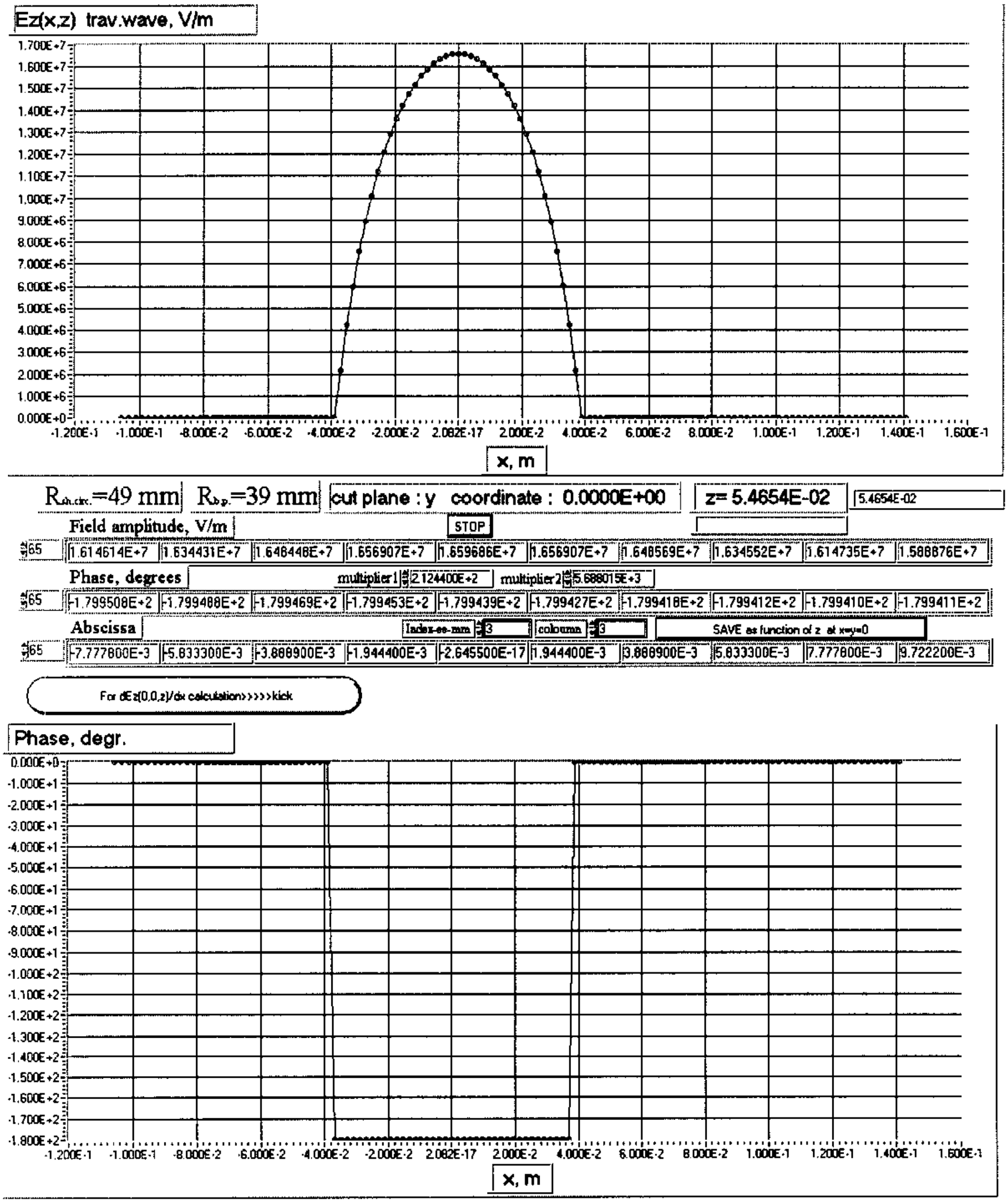


Fig.12c **z=54.7 mm**

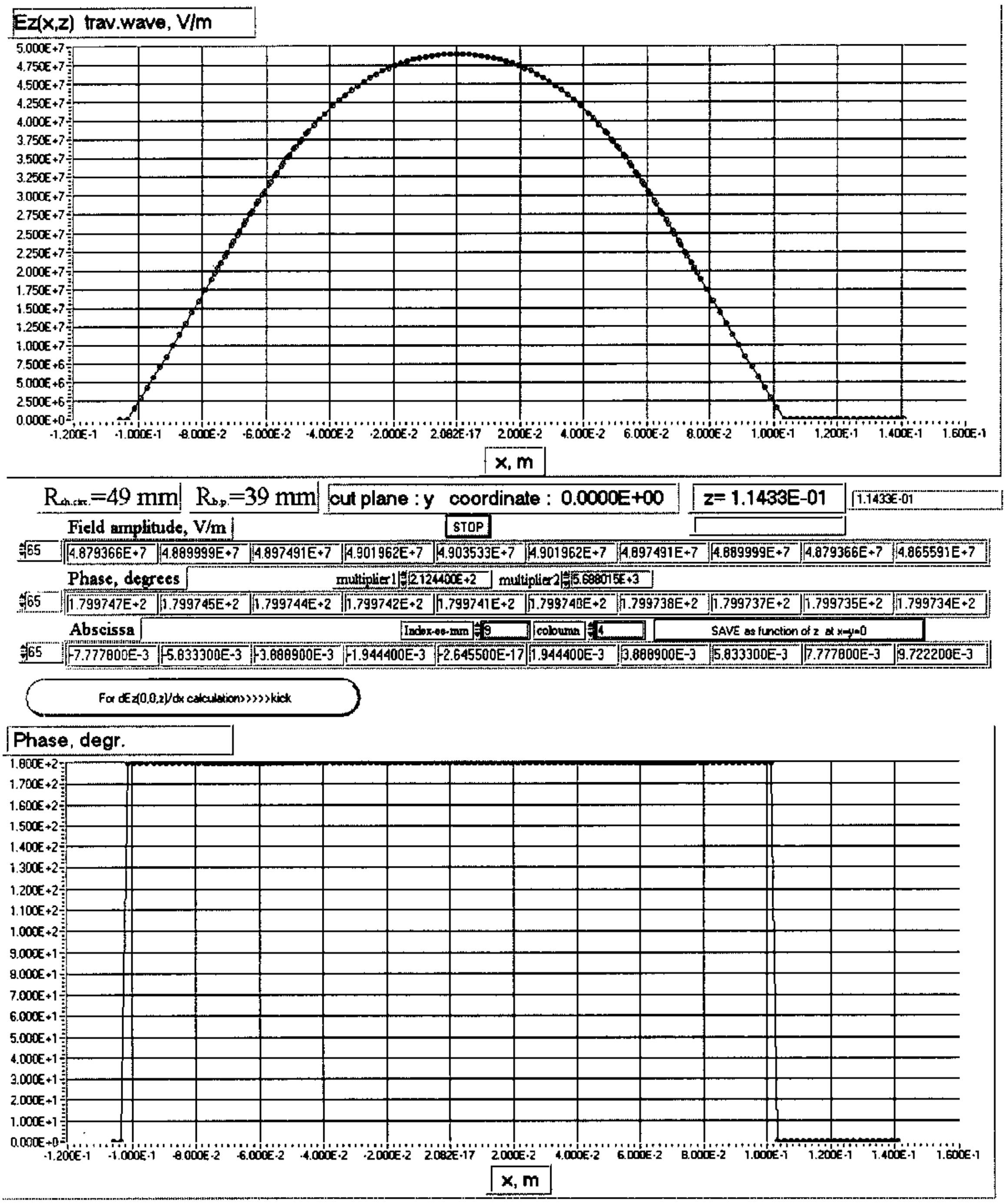


Fig.12d **z=114.3 mm**

Fig.12. E_z amplitude and phase distribution along x-axis for different values of z

In the vicinity of the cavity axis (|x|<2 mm) E_z-component has a maximum 0.517% asymmetry in the x-direction (in the RWG middle plane) and there is no asymmetry in the cell (|z|>54.7 mm).

VI. Test cavity

A one cell test-set up was designed for a high power test of the RWG coupler. The schematic design of the RWG coupler and the single resonator is shown in Fig.13.

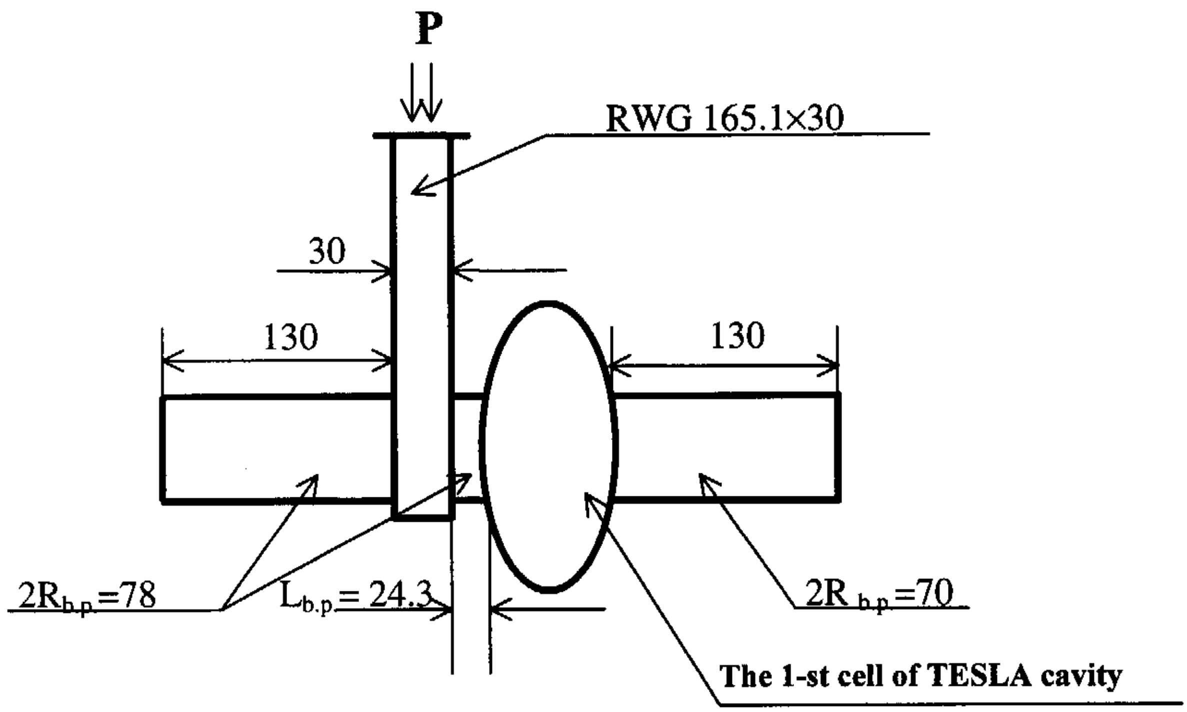


Fig.13. RWG coupler for one cell TEST-cavity

To allow a test of the high power travelling wave regime without beam and superconducting environment, the test cavity may be fabricated of copper. Q_0-factor of the copper cavity is equal to 24220 and external Q factor $Q_{ext} = Q_0$ is needed to provide the travelling wave condition in the input waveguide. The RWG coupler has the same shape and dimensions as in the RWG coupler for the two TESLA supercavities. To provide the necessary value of Q_{ext}=24220 we change the length of the beam pipe connecting RWG and one cell cavity.

The Q_{ext} dependence on the beam pipe length calculated with Kroll-Yu-method and MAFIA CODE is shown in Fig.14.

One can see that Q_{ext}=25336 (close to necessary value) corresponds to the beam pipe length $L_{b.p.}$=24.3 mm. Other dimensions of the RWG coupler and one cell cavity are shown in Fig.14. The shape and dimensions of the one cell cavity correspond to the 1-st cell of the TESLA cavity.

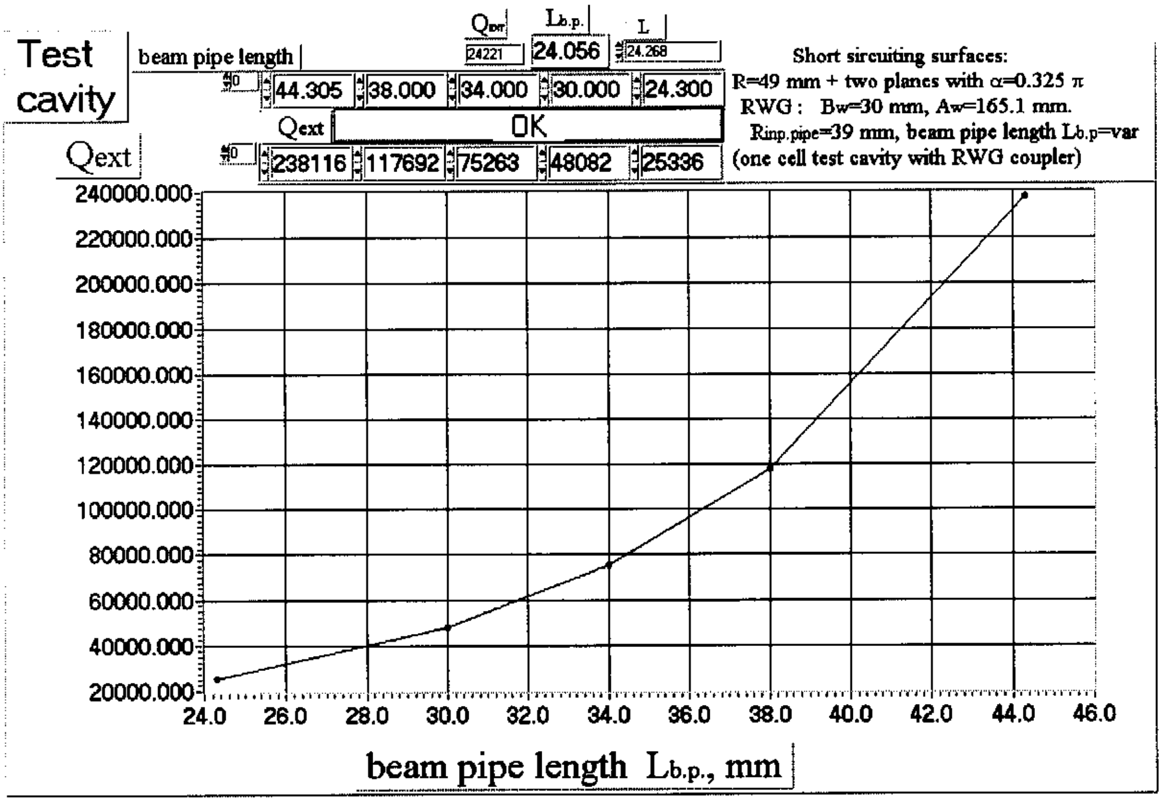


Fig.14. The dependence of external Q-factor of the one cell TEST-cavity on the beam pipe length $L_{b.p.}$

VII. Conclusion

A rectangular waveguide coupler for a double 4×7-cell TESLA supercavity (56 cell) is developed. To provide the necessary external Q-factor of the 4×7-cell TESLA supercavities the dimensions of the short-circuiting surface are determined. Such coupler provides a transmission of the high power level at low field strength and good field symmetry.

Field asymmetry, longitudinal and transverse kicks are estimated. It is shown that the ratio $Re(\Delta P_x)/\Delta P_z = 4.9\times10^{-5}$ for the 56-cell cavity. This estimation was carried out under the travelling wave regime in the beginning part of the rectangular waveguide corresponding to the beam loading effect.

A one-cell copper test cavity with RWG coupler was developed for the high power test of the RWG coupler at room temperature.

VII. References

1. W.-D.Moller ,
   Status of Input Coupler TTF-2 and TTF-3,
   The TTF Coupler Meeting, Saclay, October 19-20, 1998.
2. J.Sekutowicz, M.Ferrario, Ch.Tang,
   Superconducting Superstructure for TESLA Collider,
   DESY Print, TESLA Report 98-08, April 1998.
3. M.Dohlus, V.Kaljuzhny,
   Relative Nonunoformity in the Amplitude of the Accelerating Field Along the M×N-cell TESLA Supercavity,
   TESLA Report 98-26, November 1998.
4. D.Proch,
   Coaxial Coupler for Superstructure,
   The TTF Coupler Meeting, Saclay, October 19-20, 1998.
5. M.Zhang, Ch.Tang,
   Beam Dynamic Aspects of the TESLA Power Coupler,
   TESLA Report 98-17, July 1998.
6. H.-W.Glock, D.Hecht, U. van Rienen, M.Dohlus
   Filling and Beam Loading in TESLA superstructures
   Epac-98, 22-26 June 1998.
7. N.M.Kroll, D.U.L.Yu,
   Computer Determination of the External Q and Resonant Frequency of Waveguide Loaded Cavities,
   Particle Accelerators, 1990, Vol.34, pp.131-250.
8. M.Dohlus, N.Holtkamp, V.Kaljuzhny
   Multi-cell Cavity Excitation, Internal Report DESY M 98-05
   June 1998