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User's Guide for ABCI Version 8.8 (Azimuthal Beam Cavity Interaction)

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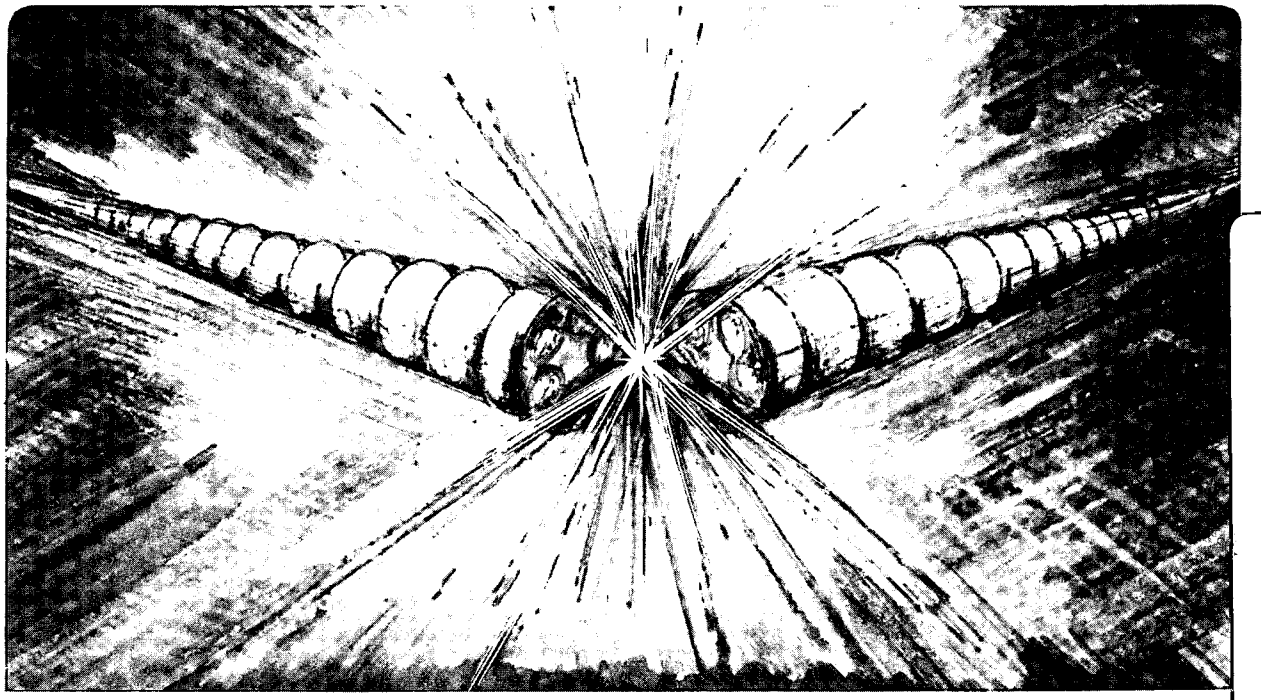

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User's Guide for ABCI Version 8.8 (Azimuthal Beam Cavity Interaction)*

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Abstract

ABCI is a computer program which solves the Maxwell equations directly in the time domain when a bunched beam goes through an axi-symmetric structure on or off axis. An arbitrary charge distribution can be defined by the user (default=Gaussian). This document is meant to be a comprehensive user's guide to describe all features of ABCI version 8.8, including also all additions since the release of the guide for version 6.2. The main advances lie in its higher speed of execution, and improved capabilities of Fourier transformations. The impedance and the frequency spectrum of deposited energy can be calculated and plotted from the Fourier transforms of the wake potentials. The "data windowing" technique can be applied to wake potentials in order to reduce the undesirable spectral leakage effect. A number of window functions can be chosen by the user. Numerical values of wake potentials as well as the Fourier transform results can be saved on separate files which can be used directly for other programs. In addition to these additions to the program, a criterion was derived for the numerical stability of the time iteration valid for the case where the longitudinal mesh size is larger than the radial one. If the time step is not fine enough to satisfy this criterion, a warning message will be issued and an appropriate value suggested. A second criterion was found to be required to guarantee the accuracy of the computed wake potentials for structures with (long) tapers. ABCI now also permits a structure with "islands", i.e. areas detached from the main body. An option was added to plot either electric field or total current lines at subsequent time steps for the monopole (m=0) case. ABCI is available as a source code in the CERN IBM VM/CMS system.

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I. Introduction

Since the release of the version 6.2 in 1992 [1], ABCI has been widely used in accelerator community to compute wake fields generated by a bunched beam passing through an axi-symmetric structure on or off axis. In many respects it had large advantages over similar programs [2], particularly due to the implementation of the "moving mesh" and the "Napoly integration" method [3]. The moving mesh option drastically reduces the number of mesh points which have to be stored, and thus allows calculation of wake potentials in very long structures and/or for very short bunches. The "Napoly integration" method improves calculation of wake potentials in structures such as collimators, where parts of the boundary extend below the beam pipe radius. Their calculation can be carried out directly with beam pipes of short length at both ends. Furthermore, the possibility of mesh sizes different in the axial and radial directions, and the possibility of using "variable" radial mesh sizes (different for different radial intervals) help for a better fitting of the mesh to the structure and often permit to reduce the total number of mesh points. With the use of TopDrawer [4], the graphic presentation of the results of the computation was greatly improved,and the installation of the program into other computers becomes much easier.

Despite these advances in its computational capability, the computational speed had not changed very much in the past. Recently, however, thanks to a thorough overhaul of the code by computer specialists at CERN [5], ABCI shows significant improvements in its computational speed. Depending on the structure and bunch length, speed-up factors of up to five have been reported.

Although a primitive form was already incorporated in older versions, the Fourier transform option of the program was quite limited. In principle, one can calculate the (effective) impedance of a structure by taking Fourier transforms of wake potentials. However, this is only true if the wake potentials can be obtained for an infinite length, or if they damp out completely over a finite length. Since the calculation of wake potentials must be terminated at some length due to the computer time limitations, the resulting impedance shows oscillatory behaviour around the actual resonant frequencies. This is actually due to "leakage" from the resonant impedance peaks to neighboring frequencies, which is caused by the truncation of the wake potentials.

A truncated wake potential can be considered as the product of an infinite long wake potential and a step function which has a unit value up to the coordinate where the it is truncated, and zero behind. The computation of the Fourier transform can be improved by multiplying the wake potential with a function which decreases more gradually to zero at the truncation. This technique is called "data windowing" [6], and a large number of different functions may be used for this purpose. This results in sharper resonant peaks with preserved area, but of varying height and width. Naturally, the impedance obtained in this way is not exact - but it must be remembered that there exists no way to obtain the exact impedance from a truncated wake potential. In the new version of ABCI, users can specify whether the data windowing technique will be applied (strongly recommended), and he can choose from three standard functions: Blackman-Harris, Kaiser-Bessel, or Gaussian functions.

In addition to these advances, ABCI now permits structures with "islands", i.e. material detached from the main body. The geometrical input should follow that of the main part.

Also the charge distribution of a bunch is no longer limited to Gaussian. It can be defined by the user by editing the BSHAPE subroutine in the source code. An option was added to plot electric field or total current lines at subsequent time steps for the monopole (m=0) case.

It is known that the time-stepping algorithm used in the FIT [7] method has an intrinsic numerical stability problem. Taflove and Brodwin [8] have derived a stability criterion for the required number of time steps in the 3-dimensional case. Weiland [9] has modified this criterion to the current 2.5 dimensional case with the open boundary conditions and equal mesh sizes in axial and radial directions. His criterion apparently is too strict, as its application to the dipole field case requires that the ratio of time step to mesh step, specified by MT in ABCI, must be at least 4, while calculations with MT=3 shows no sign of numerical instability. This contradiction is due to an overestimate of the possible maximum of the decay rate of propagating waves in all three directions.

The stability problem becomes extremely important when the axial mesh size is significantly larger than the radial one, as often preferred for structures with long and shallow tapers. In search of a more reliable criterion, the stability problem of the time-stepping algorithm was revisited, and a new criterion was derived in a (pseudo) theoretical way to fit numerical results. It can be written in terms of MT, the number of time steps required for a beam to move for one cell to another, as

$$\mathtt{MT} \geq \sqrt{(1.2 + 0.4m^2)(\frac{\Delta z}{\Delta r})^2 + 1.2} \tag{1}$$

where m is the azimuthal mode number ($m = 0$ for monopole, $m = 1$ for dipole, etc.), Δz is the axial mesh size, and Δr is the smallest radial mesh size. The derivation of this stability criterion is outlined in Appendix A. The new version of ABCI gives a warning message when the above criterion is violated and suggests an appropriate value of MT according to the above formula.

It has also been observed [10] that longitudinal and transverse (azimuthal) wake potentials for a structure with long tapers show unphysical bumps of the wrong sign at the head of the bunch before they approach the correct curve for larger values of the longitudinal coordinate. These bumps can be removed by reducing mesh sizes, but the mesh sizes necessary to ensure accurate results are normally much smaller that those required for other structures of a similar dimension. The reasons for this behaviour of tapered structures are unknown, but it can be overcome by fulfilling another criterion, roughly expressed in terms of the axial mesh size Δz as

$$\frac{a\phi}{\Delta z} \cdot \frac{\sigma_s}{\Delta z}, \gtrsim 100 \tag{2}$$

where a is the beam pipe radius, ϕ is the taper angle in radians and σ_z is the rms bunch length. The derivation of this "accuracy criterion" is given in Appendix B.

The standard output of ABCI contains the printout of all input parameters, an optional printout of the shape of a structure, numerical values of the wake potentials and their graphical representation on a line printer, and finally the loss factors. When the drawing routines are called, the Top Drawer input data will be written to a separate file. In the following section, we will explain the definitions of the input variables and how to interpret the output, referring to examples for test jobs.

II. Input Variables

Three sample input data are given in Figs. 1-3, respectively. They consist of one head line, eight **NAMELIST** formats, the input of a structure geometry, `CONTINUE` and `STOP` cards. The input format is essentially compatible to that of TBCI so that one can use the same input data for both programs with only slight changes. An example of exec files to run ABCI on the CERN IBM VM/CMS system is shown in Fig. 4.

We list all input variables with brief explanations, their units or formats, default values, and array sizes in what follows.

NAMELIST	`&FILE`	defines different ways of running the program.
`LSAV`	logical*1 (default=F)	Save the intermediate results when the CPU time is expired. A file for saving has to be allocated when `LSAV` is true. The default value of the logical device number assigned to this file is 1.
`ITEST`	(default=0)	When `ITEST=0`, ABCI computes wake fields. When `ITEST=1`, ABCI does not calculate any fields, but generates meshes for a structure to see if the input data are correct.
`LREC`	logical*1 (default=F)	Recover from a previous unfinished job, and restart of calculation. The file, which was created when `LSAV` command was executed, has to be declared for recovery. The default value of the logical device number assigned to this file is 2.
`LCPUTM`	logical*1 (default=F)	Activates the subroutine which monitors the remaining CPU time. If `LSAV` is true, `LCPUTM` becomes automatically true. When `LCPUTM=.TRUE.` and the calculation is not yet completed by the time `TMAX-TSOS` or the remaining CPU time is less than `TSOS`, ABCI stops the calculation and prints out the intermediate results on printer. To save them on a file, `LSAV` must be true.
`TSOS`	seconds (default=5.)	CPU time devoted to saving the intermediate results on a file.
`TMAX`	seconds (default=3600.)	CPU time limit for a batch job. It is required to be specified when a subroutine such as TIMEL of the CERN library that returns the remaining CPU time is not available.

TITLE FORMAT(A72)

The title of the run which may be printed as header of the program. If you do not want a title, leave it blank, but never eliminate the line.

NAMELIST	`&BOUN`	defines the boundary conditions at both ends of the structure. They are dummies for compatibility with TBCI. The boundary conditions at the ends are always "open".
`IZL`	dummy	The boundary condition at the leftmost mesh line.
`IZR`	dummy	The boundary condition at the rightmost mesh line.

NAMELIST `&MESH` defines mesh sizes for the r-and z-directions.

One can specify either the number of mesh lines or the mesh sizes.

`DDR`	meter array up to `NF`=20	Mesh sizes in the r-direction. This is actually an array. Different mesh sizes can be used for radial intervals defined by `RMARK`. For example, "`DDR=0.02, 0.01, RMARK=0.1, 0.2`" means that the mesh sizes are 0.02m from r=0.0m to r=0.1m, and 0.01m from r=0.1m to r=0.2m. When more than one mesh sizes are used, the radial coordinates of their borders are marked by arrows in a plot of the cavity shape actually used.
`DDZ`	meter	Mesh size in the z-direction. Only one mesh size can be used in the z-direction.
`NR`		Number of mesh lines in the r-direction. `NR`=(Total radius of the structure)/`DDR`+1. If this input method is chosen, only one mesh size can be used in the r-direction.
`NZ`		Number of mesh lines in the z direction. `NZ`=(Total length of the structure)/`DDZ`+1.
`RMARK`	meter array up to `NF`=20	The r coordinates which define intervals where different radial mesh sizes are applied. Between `RMARK(I)` and `RMARK(I+1)`,

		the radial mesh size is `DDR(I)`. If no value is specified, `RMARK(1)` is automatically set to be the total radius of the structure.
`RAD`	meter	The total radius of the structure. This is a dummy variable for compatibility with TBCI. ABCI finds out the total radius by itself.
`RZ`	meter array up to `NVR=100`	The values of variables `RZi` (i=1,100) which may be used in the subsequent input of the cavity geometry. The values can be specified either as `RZ=v1,v2,...,vn` or as `RZ(1)=v1, RZ(2)=v2,...,RZ(n)=vn`. If the values are specified, but not used in the input of the cavity geometry, they are ignored. One can use `-RZi` in the meaning of `-vi` in the cavity geometry input.

There are two ways to input the shape of the structure. One way is to give the absolute coordinates of the (r,z) points to be connected (the conventional input). Another way is to give the increments of coordinates (δr, δz) from the previous positions (the incremental input). The former and the latter cases are signaled by the keywords `#(##)CAVITYSHAPE` and `@(@@)CAVITYSHAPE`, respectively, for full (right half for the symmetrical case) input of structure shape. Each line contains the radial and the longitudinal coordinates. Subsequent input points can be connected by either a straight line, a circle or an ellipse, to produce a closed polygon which should be clockwise oriented.

A straight line is specified by giving a pair of coordinates to be connected in the subsequent two lines. A circular connection between points is made when an additional line is inserted between them. This line contains two numbers, i.e., the "indicator" and the radius of the circle with a sign. The first one indicates whether the shorter part (indicator=-1., or `CS`) or the longer part (indicator=-2., or `CL`) of the full circle should be taken. The curve can be either convex (radius < 0) or concave (radius > 0) with the respect to the inner area of the polygon. The absolute value of the radius will be used as the radius of the circle.

r1, z1
indicator, radius
r2, z2

The ellipse in the input can have only one orientation, with the axis parallel to r and z. The elliptical connection is made when two lines are inserted between two points to be connected. The first line contains two numbers, i.e., the indicator and a dummy. The first one indicates whether the shorter part (indicator=-3., or `ES`) or the longer part (indicator=-4., or `EL`) of the full ellipse should be used. The second one is a dummy argument and its content is ignored. The second line specifies the center of the ellipse, (rm,zm). Unlike the circular case, ABCI does not calculate the center of the ellipse by itself.

r1, z1
indicator, dummy
rm, zm
r2, z2

When the incremental input method is used, one must use `CS`,`CL`,`ES`, and `EL` instead of the corresponding negative numbers. Otherwise, ABCI interprets these numbers as the decrements of coordinates.

Any number of comments can be inserted between the first line for the origin and the last one for the origin. They must be started by the percentage symbol, "%", at the first column.

When the incremental input method is used, one can use the repetition commands ">" and "<" to repeat input blocks which are started and ended by the data cards containing the ">" and "<" symbols, respectively. The number of desirable repetitions can be specified by a number following ">" symbol. A blank, 0, and 1 mean no repetition.

The input of cavity shape geometry is a completely free format. Two numbers can be separated by blanks, a comma, or their combinations. The followings are all legal:

```
0.01, 0.1E-1
>          2
0.2D-1 -RZ1
0.03 ,     0.03
```

The following is an example of the conventional input method of the structure shape:

```
#CAVITYSHAPE (##CAVITYSHAPE)

0.0                     Dummy number. Keep it always zero.
0.0 0.0                 The first point of the polygon. Should be always 0.0, 0.0.
r1 z1
r2 z2                   Straight line connection
-1.0 -0.1               Short circle, concave connection, radius=0.1m
% This is a comment     It must be started with % at the first column.
r3 z3
EL 0.0                  Long ellipse
rm1 zm1                 Center of the ellipse
r4 z4
% Another comment.
RZ1 z5                  Variable RZ1 whose value must be given in &MESH
r6 RZ2                  Variable RZ2 whose value must be given in &MESH
......
......
0.0 0.0                 The last point of polygon (= the first one).
9999.  9999.            End of input for #(##)CAVITYSHAPE.
```

The following is an example of the incremental input method of the structure shape:

```
@CAVITYSHAPE (@@CAVITYSHAPE)
```

`0.0`	Dummy number. Keep it always zero.
`0.0 0.0`	The first point of the polygon. Should be always `0.0, 0.0`.
δr1 δz1	
δr2 δz2	Straight line connection
`CL 0.1`	Long circle, convex connection, radius=0.1m
`% This is a comment.`	It must be started with % at the first column.
δr3 δz3	
`ES 0.0`	Short ellipse
δrm δzm	The center of the ellipse
δr3 δz3	
`> 2`	Repeat twice the input block closed by ">" and "<".
RZ1 δz4	Variable RZ1 whose value must be given in `&MESH`
δr5 -RZ2	Variable RZ2 whose value must be given in `&MESH`
`<`	End of the input block to be repeated
.....	
.....	
`0.0 0.0`	The last point of polygon. Leave it `0.0, 0.0`. ABCI calculates the correct last longitudinal decrement to come back to the origin and replaces the second zero by the correct value.
`9999. 9999.`	End of input for `@(@@)CAVITYSHAPE`.

If parts of the structure are detached from the main body (so-called "islands"), the corresponding closed polygons can follow the input of the main body. They must be *anti*-clockwise oriented. Namely, the orientation of the input of structures should be determined so that the boundary always moves such that the cavity material stays on the left side. The following is an example of such a structure with islands:

`#CAVITYSHAPE (##CAVITYSHAPE)` or `@CAVITYSHAPE (@@CAVITYSHAPE)`

`0.0`	Dummy number. Keep it always zero.
`0.0 0.0`	The first point of the main structure. Should be always `0.0, 0.0`.
.....	
.....	
`0.0 0.0`	The last point of the main structure.
`r1 z1`	The first point of the first island.
.....	
.....	
`r1 z1`	The last point of the first island. (= the first one)
.....	
.....	

9999. 9999.		End of input for #(##)CAVITYSHAPE or @(@@)CAVITYSHAPE

NAMELIST	&BEAM	defines beam parameters and charge distributions.
MROT		Azimuthal mode number, i.e., MROT=0 for monopole fields or MROT=1 for dipole fields.
SIG	meter	One standard deviation of bunch length
ISIG	(default=5)	Number of standard deviations used for a Gaussian bunch.
RDRIVE	(default= beam pipe radius)	The radius of the driving hollow beam. The beam pipe radius is found by ABCI. If the beam pipe radii at both ends are unequal, the default value will be the smallest of them. If the cavity material comes down below the beam pipe radii, the default value will be the radial coordinate of the cavity material closest to the beam axis.
NBUNCH	(default=1)	Number of driving Gaussian bunches. If zero or negative, an user defined charge distribution function will be used instead of an usual Gaussian distribution. Then, the user must supply his charge distribution by editing the subroutine BSHAPE in the source code. The total charge will be automatically normalized to 1 coulomb. For more details, consult the instruction written in the subroutine BSHAPE.
BSEP	meter (default=0)	The peak-to-peak distance between bunches. Valid only when NBUNCH $\geq$ 2.

NAMELIST	&TIME	
MT	(default=3) up to 20	Number of time steps for a beam to move from one cell to another. (It will be automatically changed to MT=4 when LCHIN=.TRUE. and MROT=1). If the user's chosen value is not large enough to satisfy the stability criterion (1), a warning message will be issued with a suggested value. Calculation continues despite of the warning.
NSHOT	(default=5)	Total number of plots of electric field

		lines or total current lines at subsequent time steps for the monopole case (MROT=0). Plots are made at equally spaced time steps.
TPS	pico seconds	The first time step at which electric field lines or total current lines are plotted. The default value is (the total time needed for a bunch to pass through a structure)/NSHOT.

NAMELIST	&WAKE	specifies the calculation of wake potentials.
UBT	meter (defaults=10*SIG)	The last longitudinal coordinate relative to the head of the beam, up to which the wake potentials are calculated. This parameter defines the window length.
LCFRON	logical*1 (default=T)	Window suppressing calculation of fields in front of the bunch.
LCBACK	logical*1 (default=T)	Window suppressing calculation of fields behind the bunch. If LPLE or LPLC is true, LCBACK must be false. Then, the moving mesh option is suppressed.
LCHIN	logical*1 (default=F)	When LCHIN=.TRUE., wake potentials for MROT=1 case are calculated by means of Chin's method. The beam moves continuously, and wake fields are sampled at equal time steps. When LCHIN=.FALSE., the beam jumps to next cell every MT time steps.
LNAPOLY	logical*1 (default=F)	When LNAPOLY=.TRUE., the Napoly method of wake potential calculation is used for both MROT=0 and MROT=1 cases. If the beam pipe radii at both ends are unequal, or the cavity material comes down below the beam pipe radii, one must use the Napoly method. If LNAPOLY is yet false, ABCI changes it to LNAPOLY=.TRUE., and finds an appropriate integration contour (its validity should still be checked by the user). The integration contour can be specified by the user, using ZCF, ZCT and RWAK. For MROT=1 case, unequal beam radii are not allowed (ABCI will skip the calculation in that case). For more details, see the ref. [1].
ZCF	meter	The z-coordinate in the cavity frame

		at which the Napoly-Zotter integration contour shifts from r=the radius of the left beam pipe to r=RWAK. See Fig. 5.
ZCT	meter	The z-coordinate in the cavity frame at which the Napoly-Zotter integration contour shifts from r=RWAK to the radius of the right beam pipe. See Fig. 5.
RWAK	meter	The r-coordinate in the cavity frame where the Napoly-Zotter integration contour runs horizontally between z=ZCF and z=ZCT. See Fig. 5.

NAMELIST	&PLOT	controls the plot of results in the form of Top Drawer [4] input file. The default value of the logical device number assigned to this file is 9.
LCAVIN	logical*1 (default=F)	Plot cavity shape input.
LCAVUS	logical*1 (default=F)	Plot cavity shape actually used. When more than one radial mesh sizes are used, the radial coordinates of their borders are marked by arrows in the plot.
LPLW	logical*1 (default=F)	Plot all wake potentials.
LPLWL	logical*1 (default=F)	Plot the longitudinal wake potential.
LPLWA	logical*1 (default=F)	Plot the azimuthal wake potential.
LPLWT	logical*1 (default=F)	Plot the transverse wake potential.
LFFT	logical*1 (default=F)	Calculate the real and imaginary parts of all impedance, and plot them.
LFFTL	logical*1 (default=F)	Calculate the real and imaginary parts of longitudinal impedance and plot them.
LFFTA	logical*1 (default=F)	Calculate the real and imaginary parts of azimuthal impedance and plot them.
LFFTT	logical*1 (default=F)	Calculate the real and imaginary parts of transverse impedance and plot them.
LINTZ	logical*1 (default=F)	Integrate the real part of each impedance over frequency and plot it as a function of the upper limit of this integration. This option is useful to find areas of each resonance peak.
LSPEC	logical*1	Calculate the frequency spectrum of a

	(default=F)	longitudinal loss factor (or deposited energy) and its integration over frequency as a function of the upper limit of frequency of this integration and plot them. This option is applied only to `MROT=0` case.
`LWNDW`	logical*1 (default=T)	When `LWNDW=.TRUE.`, the data windowing [6] is applied to wake potential data to reduce the undesirable effects related to spectral leakage.
`NWFUN`	(default=1)	Choice of the window functions. 1 → Kaiser-Bessel window. 2 → 4-term 74db Blackman-Harris window. 3 → Gaussian window.
`ALPHA`	(default=3.0)	Alpha parameter of the window functions.
`CUTOFF`	GHz	The cutoff frequency for plots of the Fourier transforms of wake potentials. The default value of `CUTOFF` is determined so that the exponential correction factor due to the bunch length, $\exp((2\pi \mathtt{CUTOFF} \cdot \mathtt{SIG})^2/2c^2)$, is 20 where c is the speed of light. An user's specified value is used if smaller than the default value.
`LPLE`	logical*1 (default=F)	Plot electric field lines at subsequent time steps for the monopole case (`MROT=0`). If this is true, `LCBACK` must be false.
`LPLC`	logical*1 (default=F)	Plot total current lines at subsequent time steps for the monopole case (`MROT=0`). If this is true, `LCBACK` must be false.
`NPLOT`	(default=10)	Number of field lines that a bunch carries when it enters a structure. At the default mode, the field lines of given strength are plotted, and thus the number of field lines may vary from one plot to another.
`LPALL`	logical*1 (default=F)	When `LPALL=.TRUE.`, the mode of field line plotting is switched to the mode in which a fixed number of field lines (specified by `NPLOT`) are plotted at each time step, regardless of the strength of remnant wake fields.

NAMELIST	`&PRIN`	controls the printout of results.
`LPRW`	logical*1 (default=F)	Print numerical values of all wake potentials on line printer.
`LMATPR`	logical*1 (default=F)	Print cavity shape actually used on line printer.
`LSVW`	logical*1	Save numerical values of all wake potentials

	(default=F)	on a separate file. When MROT=1, they are normalized by the transverse offset of the driving beam. The default value of the logical device number assigned to this file is 8.
LSVWL	logical*1 (default=F)	Save numerical values of the longitudinal wake potential on a separate file. When MROT=1, they are normalized by the transverse offset of the driving beam.
LSVWA	logical*1 (default=F)	Save numerical values of the azimuthal wake potential on a separate file. They are normalized by the transverse offset of the driving beam.
LSVWT	logical*1 (default=F)	Save numerical values of the transverse wake potential on a separate file. They are normalized by the transverse offset of the driving beam.
LSVF	logical*1 (default=F)	Save Fourier transform results (impedance, etc.) on a separate file. This option is effective only when LFFT=.TRUE.. The default value of the logical device number assigned to this file is 8.

The calculation can be continued for another set of input parameters if one puts

```
CONTINUE
```

card behind **NAMELIST** &PRIN. Then **NAMELIST** &MESH, &BEAM, &WAKE, &PLOT and &PRIN formats can follow. Only the changed parameters need to be specified. The calculation can be again continued by putting CONTINUE card after them, followed by another set of **NAMELIST** formats. The program stops when the command card

```
STOP
```

is detected.

III. Output of ABCI

The outputs for the test inputs given by Figs. 1-3 are shown in Figs. 6-8, respectively. We will briefly explain how to interpret the output for the reader's convenience. The beginning of the output is signalled by the title of the program followed by the date, time and the version number of ABCI. All the input variables are printed with short explanations of their definitions and with their units. Next follows the printout of the actually used cavity shape. Then a normalized line-printer plot of the wake potentials, the scaling and the loss factors are printed. The transverse wake is calculated from the longitudinal one using the Panofsky-Wentzel relationship. If LPRW=.TRUE., numerical values of the wake potentials are printed on line printer as a function of distance from the bunch head. If LSVW=.TRUE. and/or

LSVF=.TRUE., numerical values of the wake potentials and/or Fourier transform results are saved on a separate file called fn WAKEPOT, where fn is the file name of your input data. These data may be used directly for other programs if desired. If any flag of **NAMELIST** &PLOT is true, a Top Drawer [4] input file for the corresponding plots are created in a file called fn TOPDRAW, where fn is the file name of your input data. In order to view plots, you must execute a local Top Drawer command on this file.

In a batch job, if the specified CPU time was not enough to complete the calculation and LCPUTM is true, the last time step computed will be printed and a warning message will be issued. Wake potentials and loss factors will also be printed (and plotted), however, they should not be believed. If LSAV is true, the intermediate results of the computation will be stored in a file specified by the user. The default value of the logical device number assigned to this file is 1. In order to recover the intermediate results from the file using LREC command, the same file must be assigned to the logical device number 2.

Important change: From this version, numerical values of wake potentials and loss factors are printed in units of per pico coulomb. For the dipole (m=1) case, they are normalized by the transverse offset of the driving beam. Longitudinal wakes of the m=1 case are further normalized by the transverse offset of the test particle where wake forces are integrated.

IV. How To Run ABCI

If you are an user of the CERN IBM VM/CMS, you must have access to the LEPTH disk, where you will find a copy of the files: ABCI FORTRAN (source code), ABCI EXEC (EXEC file for executing ABCI), ABCI HELPCMS file and three sample data files SAMPLE# ABCI (# = 1-3). The content of the ABCI EXEC file is shown in Fig. 4 for the reader's convenience. In order to run the program, you must have a data file on the A-disk, called fn ABCI. (For test purposes, you can copy the SAMPLE# ABCI (# = 1-3) files from the LEPTH disk). Then type in:

```
ABCI fn
```

The results will be on the file fn RESULTS on your A-disk. The Top Drawer input data will appear on the file fn TOPDRAW on your A-disk, if any flag in &PLOT is true. Numerical values of wake potentials and/or Fourier transform results will be saved on the file fn WAKEPOT on your A-disk, if LSVW and/or LSVF are true. If the specified CPU time was not enough to complete the calculation and LCPUTM is true, the intermediate results are dumped onto the file fn ABCSAVE on your A-disk.

V. How To Install ABCI into Other Computers

ABCI has been written in the standard Fortran 77. Since it creates a Top Drawer input file, rather than plots figures by itself, it contains no drawing routines. It is written to be self-sufficient, except it calls a few external routines from the CERN library. They are related to the date and time of job execution and the job cpu time, and serve merely as accessories for the convenience of users. They are:

TIMEX(T)	returns execution time in seconds used so far.
TIMEL(T)	returns execution time remaining in seconds until time limit.
TIMEST(T)	initializes the time operation.
DATIMH(DATE,TIME)	returns the current calender date and time.

All these routines are collected together in the subroutines, CPUTIM, CPULFT and DATIME, at the end of ABCI.

If you are an user of vax, SUN or Hewlett-Packard (HP) computers, a FORTRAN library called DATLIB FORTRAN is available from the author, in which the above four routines from the CERN library are replaced by corresponding local routines. Just copy it to the end of the ABCI source code or link its object module with that of ABCI, then ABCI becomes completely self-sufficient. If the IMSL or NAGLIB packages are available in your computer, special version of the DATLIB for them are also available.

VAX users who don't use the DATLIB library must locate "FOR VAX USERS" comments, and comment out "CHARACTER*8 NDATE, NTIME" comments, and include lines containing "REAL*8 NDATE, NTIME" instead. SUN and HP users must locate two "FOR SUN AND HP USERS" comments in the subroutine PLTMSH and comment out lines which contain back slash characters " \", and include lines which contains characters L instead.

Users of some computers may have to change the logical device numbers assigned to input and output files. It can be done by editing the content of BLOCKDATA DEVNUM subroutine in the source code. See the instruction there. Their default values are

Device Number:

1 ⟶	A file created by ABCI to save intermediate results when the CPU time is expired and LSAV=.TRUE. in &FILE.
2 ⟶	The same file as the one created when LSAV command was executed. It is used to recover from a previous unfinished job when LREC=.TRUE. in &FILE.
5 ⟶	An ABCI input file.
6 ⟶	An ABCI output file.
8 ⟶	A file created by ABCI to save numerical values of wake potentials and/or Fourier transform results when LSVW=.TRUE. and/or LSVF=.TRUE. in &PRIN.
9 ⟶	An input file created by ABCI for TopDrawer for plots when any flag of &PLOT is true.

The array sizes are preset by the PARAMETER commands. They are:

NMESH	The maximum number of mesh points in the window.
NWN	The maximum number of wake potential points.
NBP	The maximum number of lines for the structure geometry input.
NVR	The maximum number of variables, RZi, used in the geometry input.

NF	The maximum number of different radial mesh sizes.
NRN	The maximum number of radial mesh lines.
NSP	The maximum number of intersections between the structure and the mesh in the connection of two subsequent points.
NPF	The number of points in frequency in Fourier transforms.
NPT	The maximum number of MT
NHIT	For internal use. Keep it comparable to NMESH.

They can be changed easily. See the instructions at the head of ABCI source code.

Acknowledgements

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Appendix A: Derivation of the Stability Criterion

We closely follow the derivation by Taflove and Brodwin in the 3-dimensional case [8]. For convenience, we choose the following convention: $\mu = \epsilon = c = 1$, where μ and ϵ are the permeability and the permittivity of the vacuum, respectively, and c is the speed of light. The Maxwell equations can be then written as

$$i\nabla \times \vec{V} = \frac{\partial}{\partial t}\vec{V}, \tag{3}$$

where

$$\vec{V} = \vec{H} + i\vec{E}, \tag{4}$$

and $\vec{H}$ and $\vec{E}$ are magnetic and electric field vectors. The stability of the numerical representation of Eq. (3) can be studied by investigating the following pair of eigenvalue equations:

$$\frac{\partial}{\partial t}|_{\text{numerical}}\vec{V} = \lambda\vec{V}, \tag{5}$$

and

$$i\nabla|_{\text{numerical}} \times \vec{V} = \lambda\vec{V}. \tag{6}$$

The FIT method [7] replaces the first equation by a finite time difference equation:

$$\frac{\vec{V}^{n+1/2} - \vec{V}^{n-1/2}}{\Delta t} = \lambda\vec{V}^n, \tag{7}$$

where Δt is the time step. If we define a growth rate of the solution, $q = \vec{V}^{n+1}/\vec{V}^n$, and substitute it into Eq. (7), we get a solution for q

$$q = \frac{\lambda\Delta t}{2} \pm \sqrt{1 + (\frac{\lambda\Delta t}{2})^2}. \tag{8}$$

The stability of the time iteration in Eq. (7) can be ensured if $|q| \leq 1$ for all possible spatial modes in the mesh. This condition leads to

$$\Re\lambda = 0, \qquad |\Im\lambda| \leq \frac{2}{\Delta t}. \tag{9}$$

Next, let us examine the second Eq. (6). We assume that an arbitrary spatial mode with azimuthal mode number m can be expressed at mesh point $(r = l\Delta r, z = n\Delta z)$ as

$$\vec{V}(l,m,n) = \vec{V}_0 \exp[\, i(k_r l\Delta r + m\phi + k_z n\Delta z)\,], \tag{10}$$

where k_r and k_z are the wave numbers in the radial and axial directions, respectively. For such a mode, the FIT method replaces the radial and axial space derivatives in Eq. (6) by the following finite space difference equations:

$$\frac{\partial\vec{V}(l,m,n)}{\partial r} = \frac{\vec{V}(l+\frac{1}{2},m,n) - \vec{V}(l-\frac{1}{2},m,n)}{\Delta r}, \tag{11}$$

and

$$\frac{\partial \vec{V}(l,m,n)}{\partial z} = \frac{\vec{V}(l,m,n+\frac{1}{2}) - \vec{V}(l,m,n-\frac{1}{2})}{\Delta z}, \tag{12}$$

respectively. For the azimuthal direction, the space derivative becomes simply

$$\frac{1}{r}\frac{\partial \vec{V}(l,m,n)}{\partial \phi} = i\frac{m}{(l+\frac{1}{2})\Delta r}\vec{V}. \tag{13}$$

If we apply Eqs. (11-13) into Eq. (6), we get

$$-2\,(\,\frac{\sin(\frac{1}{2}k_r\Delta r)}{\Delta r}, \frac{m}{2(l+\frac{1}{2})\Delta r}, \frac{\sin(\frac{1}{2}k_z\Delta z)}{\Delta z}\,) \times \vec{V}(l,m,n) = \lambda \vec{V}(l,m,n). \tag{14}$$

A solution of the above equation is

$$\lambda = \pm 2i\sqrt{\frac{\sin^2(\frac{1}{2}k_r\Delta r)}{\Delta r^2} + (\frac{m}{2(l+\frac{1}{2})\Delta r})^2 + \frac{\sin^2(\frac{1}{2}k_z\Delta z)}{\Delta z^2}}. \tag{15}$$

Let us define α_r, α_ϕ and α_z as

$$\sin^2(\frac{1}{2}k_r\Delta r) = \alpha_r, \tag{16}$$

$$(\frac{1}{2(l+\frac{1}{2})})^2 = \alpha_\phi, \tag{17}$$

and

$$\sin^2(\frac{1}{2}k_z\Delta z) = \alpha_z. \tag{18}$$

To satisfy the stability condition (9) for an arbitrary spatial mode, we need

$$2\sqrt{\frac{\alpha_r}{\Delta r^2} + \alpha_\phi\frac{m^2}{\Delta r^2} + \frac{\alpha_z}{\Delta z^2}} \leq \frac{2}{\Delta t}. \tag{19}$$

This condition can be rewritten in terms of $\mathtt{MT} = \Delta z/\Delta t$ as

$$\sqrt{(\alpha_r + \alpha_\phi m^2)(\frac{\Delta z}{\Delta r})^2 + \alpha_z} \leq \mathtt{MT}. \tag{20}$$

Let us estimate the largest possible α_r, α_ϕ and α_z. From the sampling theorem, we know that the highest frequency to be seen in a mesh of the size Δ is given by

$$\omega_{max} = \frac{\pi \cdot c}{\Delta}. \tag{21}$$

The corresponding largest wave number is

$$|k_{max}| = \frac{\pi}{\Delta}. \tag{22}$$

Since waves can propagate away from the structure through open boundaries, their wave numbers are in general complex. Then, the sampling theorem must be extended into the

complex frequency. It is reasonable to assume that Eqs. (21) and (22) still hold in the extended sampling theorem. A question is how much imaginary part k_{max} can have. A clue to this question may be obtained from the resonator model of impedance. In this model, cavity modes have complex mode frequencies

$$\omega = \omega_r S + i\frac{\omega_r}{2Q}, \tag{23}$$

where ω_r is the resonant frequency, Q is the Q-value, and $S = \sqrt{1 - 1/(4Q^2)}$. If we equate ω_r to ω_{max}, the wave number belonging to this highest frequency is given by

$$k = \pm(|k_{max}|S + i\frac{|k_{max}|}{2Q}), \tag{24}$$

where $|k_{max}|$ is given by Eq. (22). For a fast decaying mode with Q to be $1 \sim 2$, the upper limit of α_v ($v = r$ or z) is given by

$$\sin^2(\frac{1}{2}k\Delta) \leq 1.76 \quad \text{for Q=1}, \tag{25}$$

and

$$\sin^2(\frac{1}{2}k\Delta) \leq 1.16 \quad \text{for Q=2}. \tag{26}$$

The parameter α_ϕ takes the largest value when $l = 0$:

$$(\frac{1}{2(l+\frac{1}{2})})^2 = \alpha_\phi \leq 1. \tag{27}$$

We have estimated the reasonable range of values for each parameter α_r, α_ϕ and α_z in Eq. (20). To remove ambiguities still left, a number of calculations have been made for many structures to fix these parameters numerically so that the stability criterion (20) can fit calculation results well. We made an Ansatz that $\alpha_r = \alpha_z$. Then, the best fitting parameters were found to be

$$\alpha_r = \alpha_z = 1.2, \tag{28}$$

and

$$\alpha_\phi = 0.4. \tag{29}$$

The stability condition (20) can be written explicitly as

$$\sqrt{(1.2 + 0.4m^2)(\frac{\Delta z}{\Delta r})^2 + 1.2} \leq \mathrm{MT}. \tag{30}$$

Appendix B: Derivation of the Accuracy Criterion for a Structure with a Taper

Consider a beam entering a taper from a beam pipe. In the beam pipe, the field surrounding the beam is almost a plane wave. This wave is diffracted at the edge between the beam pipe and the taper when the beam enters the taper. If the diffracted wave has the wave length much shorter than the beam pipe radius, it mostly stays in a small opening

angle $\sim 1/k_z a$, where k_z is the longitudinal wave number. As shown in Appendix A, the sampling theorem says that the largest wave number to be seen in a mesh of the size Δz is given by

$$k_{max} = \frac{\pi}{\Delta z}. \tag{31}$$

If the taper angle ϕ is smaller than $1/k_{max}a$, no diffracted wave can be expressed correctly by this mesh. In other words, the mesh is no longer able to represent fields in the taper accurately enough. Therefore, we need the condition

$$1 \ll k_{max} a\phi = \frac{\pi}{\Delta z} a\phi \tag{32}$$

for the convergence of computation results.

Let us write the above condition in a more quantitative form for practical usage. We define a critical wave number, k_c, at which the diffraction angle of the wave is equal to the taper angle:

$$k_c = \frac{1}{a\phi}. \tag{33}$$

Let us define a parameter η to be

$$\eta = \frac{k_{max}}{k_c} = \frac{\pi a\phi}{\Delta z}. \tag{34}$$

The task now is to find the minimum value of η, η_{min}, above which the convergence of results is guaranteed. Obviously, the value of η_{min} depends on the bunch length σ_z, since we need lower frequencies to be expressed by the mesh for a longer bunch. Let us define another parameter ξ to be

$$\xi = \frac{k_{max}}{1/\sigma_z} = \frac{\pi\sigma_z}{\Delta z}. \tag{35}$$

The parameter ξ expresses how high a frequency range the mesh can represent in units of $1/\sigma_z$, the rms value of the bunch spectrum in wave number. It is difficult to find an exact relationship between η_{min} and ξ, but in general, we need a smaller η_{min} for a larger ξ. We thus make an Ansatz:

$$\eta \sim \frac{b}{\xi}. \tag{36}$$

Combining Eq. (34)-(36), we have the criterion

$$\frac{\eta_{min} b}{\pi^2} \lesssim \frac{a\phi}{\Delta z} \cdot \frac{\sigma_z}{\Delta z}. \tag{37}$$

We have determined the parameter $\eta_{min} b/\pi^2$ from numerous numbers of calculation for different combinations of parameters. It was found to be roughly

$$100 \lesssim \frac{a\phi}{\Delta z} \cdot \frac{\sigma_z}{\Delta z}. \tag{38}$$

```
 &FILE  LSAV=.F., ITEST=0, LREC=.F.  &END
 SAMPLE INPUT #1  A SIMPLE CAVITY STRUCTURE
 &BOUN  IZL=3, IZR=3  &END
 &MESH  DDR=.005, DDZ=.005  &END
 ##CAVITYSHAPE
0.
0.000 0.000
0.210 0.000
0.210 0.115
0.180 0.135
0.130 0.135
0.070 0.095
-1., 0.009
0.060 0.097
0.060 0.150
0.000 0.150
0.000 0.000
9999. 9999.
 &BEAM  SIG=0.020, MROT=0  &END
 &TIME  MT=3  &END
 &WAKE  &END
 &PLOT  LCAVIN=.T., LCAVUS=.T., LPLW=.T.  &END
 &PRIN  LMATPR=.T.  &END
CONTINUE
 &BEAM  SIG=0.030, MROT=1  &END
 &PLOT  LCAVIN=.F., LCAVUS=.F., LPLW=.T.  &END
CONTINUE
 &MESH  DDR=.005, 0.0075, 0.005, 0.0075, DDZ=.005,
      RMARK=.070, 0.1300, 0.180, 0.2100  &END
 &BEAM  SIG=0.020, MROT=0  &END
 &WAKE  UBT=8.00 &END
 &PLOT  LCAVIN=.F., LCAVUS=.T., LPLW=.T., LFFTL=.T., LSPEC=.T. &END
STOP
```

Figure 1: Sample input # 1.

```
 &FILE  LSAV=.F., ITEST=0, LREC=.F.  &END
 SAMPLE INPUT #2  A COLLIMATOR-LIKE STRUCTURE WITH DOUBLE TEETH
 &BOUN  IZL=3, IZR=3  &END
 &MESH  DDR=.002, DDZ=.002, RZ=0.010, 0.030  &END
 @CAVITYSHAPE
0.
0.000 0.000
0.030 0.000
0.000 0.030
0.010 0.000
ES, 0.0000
0.000 0.010
0.020 0.000
> 2
ES, 0.0000
-.020 0.000
0.000 0.010
-.020 0.000
CS, 0.010
0.000 0.020
0.020 0.000
ES, 0.0000
0.000 0.010
0.020 0.000
<
ES, 0.0000
-.020 0.000
0.000 0.010
-RZ1  0.000
0.000 0.030
-RZ2  0.000
0.000 0.000
9999. 9999.
 &BEAM  SIG=0.020, MROT=0  &END
 &TIME  MT=3 &END
 &WAKE  LNAPOLY=.T.  &END
 &PLOT  LCAVIN=.T., LCAVUS=.T., LPLW=.T.  &END
 &PRIN  LMATPR=.T.  &END
CONTINUE
 &BEAM  SIG=0.020, MROT=1  &END
CONTINUE
 &MESH  DDR=.002, DDZ=.002, RZ=0.025, 0.015  &END
 &BEAM  SIG=0.020, MROT=0  &END
 &WAKE  LNAPOLY=.T., ZCF=0.020, ZCT=0.15, RWAK=0.010  &END
 &PLOT  LCAVIN=.T., LCAVUS=.F., LPLW=.T.  &END
STOP
```

Figure 2: Sample input # 2.

```
 $FILE  LSAV=.F., ITEST=0, LREC=.F.  $END
 SAMPLE INPUT #3  A MONITOR-LIKE STRUCTURE WITH A CUTTING EDGE
 $BOUN  IZL=3, IZR=3  $END
 $MESH  DDR=.0005, DDZ=.0005  $END
 #CAVITYSHAPE
0.00
0.000  0.000
0.020  0.000
0.020  0.010
0.019  0.010
0.019  0.012
0.020  0.012
0.020  0.022
0.000  0.022
0.000  0.000
0.016  0.005
0.016  0.017
0.0165 0.017
0.0165 0.012
0.0175 0.012
0.0175 0.010
0.0165 0.010
0.0165 0.005
0.016  0.005
9999. 9999.
 $BEAM  SIG=0.0020, MROT=0, NBUNCH=2, BSEP=0.02 $END
 $TIME  MT=3, NSHOT=7  $END
 $WAKE  LNAPOLY=.T., LCBACK=.F.  $END
 $PLOT  LCAVIN=.F., LCAVUS=.F., LPLW=.T., LPLE=.T.  $END
 $PRIN  LMATPR=.T., LSVW=.T. $END
STOP
```

Figure 3: Sample input # 3.

```
/* RUNNING ABCI VERSION 8.8 February 1994 */
arg fn  .
'EXEC CERNLIB NAGLIB GENLIB'
'FIlEDEF 5 DISK' fn 'ABCI A (PERM'
'FILEDEF 6 DISK' fn 'RESULTS A (PERM'
'FI 1 DISK' fn 'ABCSAVE  A4 (RECFM VBS LRECL 32756 BLKSIZE 12000 PERM'
'FI 2 DISK' fn 'ABCSAVE  A4 (RECFM VBS LRECL 32756 BLKSIZE 12000 PERM'
'FILEDEF 8 DISK' fn 'WAKEPOT A (PERM'
'FILEDEF 9 DISK' fn 'TOPDRAW A (PERM'
/* 'EXEC VFORT ABCI (NOSOURCE NOMAP NOPRINT GO' */
'LOAD ABCI (NOAUTO CLEAR'
'START * NOXUFLOW'
exit
```

Figure 4: ABCI EXEC file to run ABCI on CERN IBM VM/CMS system.

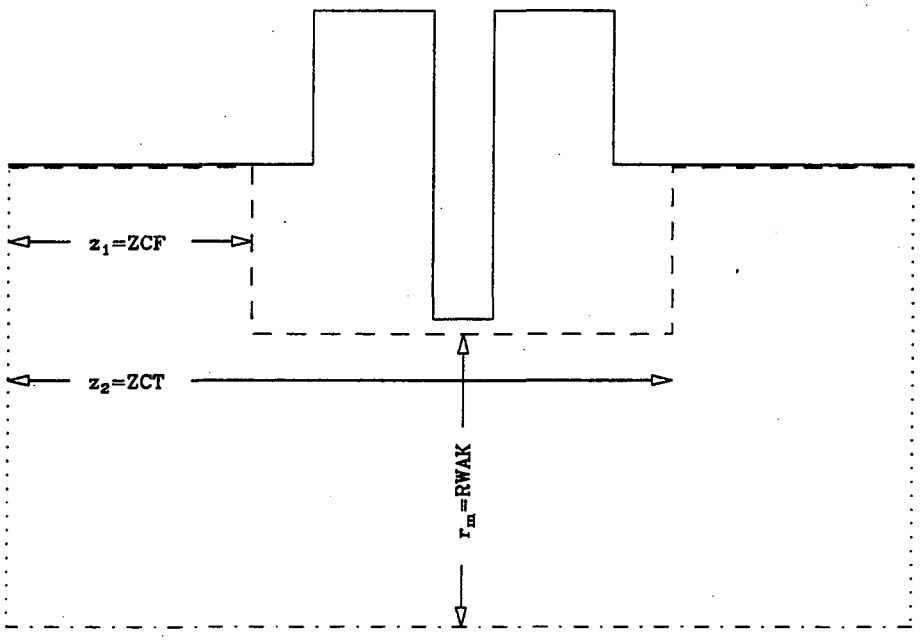

Figure 5: Napoly-Zotter contour.

```
*************************************************************************
*                                                                       *
*                                ABCI                                   *
*                                                                       *
* Azimuthal Beam Cavity Interaction in a cylindrically symmetric structure *
*                                                                       *
*  SAMPLE INPUT #1  A SIMPLE CAVITY STRUCTURE                           *
*                                                                       *
*     DATE:10/03/94   TIME:20.20.30     VERSION 8.8,  FEBRUARY  1994    *
*                                                                       *
*************************************************************************


$FILE:
SAVE FIELDS INTO FILE   (LSAV)   :  F
RECOVER FROM FILE       (LREC)   :  F
CPUTIME MONITOR ACTIVE  (LCPUTM):  F

$BOUN:
BOUNDARY CONDITIONS      LEFT   : OPEN
BOUNDARY CONDITIONS      RIGHT  : OPEN

$MESH:
NUMBER OF MESH LINES IN R       : NR   =      43
NUMBER OF MESH LINES IN Z       : NZ   =      60
NUMBER OF MESH POINTS           : NP   =    1935
TOTAL RADIUS OF THE STRUCTURE   : RAD  =  0.21000     (M)
TOTAL LENGTH OF THE STRUCTURE   : ZL   =  0.30000     (M)
STEP SIZE IN R                  : DDR  =  0.50000E-02(M)
STEP SIZE IN Z                  : DDZ  =  0.50000E-02(M)

#CAVITYSHAPE (##CAVITYSHAPE) :  HALF CELL INPUT

INPUT:        (R, Z)                      (IR, IZ)
(   0.00000E+00  0.00000E+00 )  (       1       1 )
(   0.21000      0.00000E+00 )  (      43       1 )
(   0.21000      0.11500     )  (      43      24 )
(   0.18000      0.13500     )  (      37      28 )
(   0.13000      0.13500     )  (      27      28 )
(   0.70000E-01  0.95000E-01 )  (      15      20 )
CONNECTED BY A CONCAVE CIRCLE, IKIND=-1,  RADIUS=  0.90000E-02
(   0.60000E-01  0.97000E-01 )  (      13      20 ) ---> (   0.60000E-01  0.95000E-01 )
(   0.60000E-01  0.15000     )  (      13      30 )
(   0.00000E+00  0.15000     )  (       1      31 )
(   0.00000E+00  0.00000E+00 )  (       1       1 )

$BEAM:
SIGMA OF THE GAUSSIAN BUNCH     : SIG  =  0.20000E-01(M)
NUMBER OF STAND.DEV. USED       : ISIG = +/-  5
RADIAL BEAM OFFSET AT           :RDRIVE=  0.60000E-01(M)
MODE NUMBER (MONOPOLE/DIPOLE)   : MROT =      0

$WAKE:
RADIAL WAKE OFFSET        (LEFT)   AT  R   =  0.60000E-01(M)
WAKE    BETWEEN THE BUNCH  COORDINATES UBF =  0.00000E+00(M)
                                   AND UBT =  0.20000     (M)
WINDOW FOR FRONT                  (LCFRON)  :  T
WINDOW FOR BACK                   (LCBACK)  :  T
CHIN WAKE INTEGRATION METHOD      (LCHIN )  :  F
```

Figure 6: Output for the sample input # 1.

```
NAPOLY WAKE INTEGRATION METHOD   (LNAPOLY) :  F
NUMBER OF WAKE POTENTIAL POINTS: NW    =      41

$TIME:
TIME STEPS TO BE PROCESSED      : NT    =    304
NUMBER OF TIME STEPS/MESH STEP  : MT    =      3
VELOCITY OF THE BUNCH / C       : BETA  =   1.0000
TIME-STEP VALUE                 : DT    =   5.5594    (PS)
TIME FOR A PARTICLE TO PASS     : PT    =   1000.7    (PS)

$PLOT:
PLOT OF CAVITY SHAPE INPUT        (LCAVIN)  :  T
PLOT OF CAVITY SHAPE USED         (LCAVUS)  :  T
PLOT OF ALL WAKE POTENTIALS       (LPLW)    :  T
PLOT OF AZIMUTHAL WAKE POTENTIAL  (LPLWA)   :  F
PLOT OF TRANSVERSE WAKE POTENT.   (LPLWT)   :  F
PLOT OF LONGITUDINAL WAKE POTENT. (LPLWL)   :  F
PLOT OF FFT OF WAKE POTENTIALS    (LFFT)    :  F
PLOT OF FFT OF AZIMUTHAL WAKE     (LFFTA)   :  F
PLOT OF FFT OF TRANSVERSE WAKE    (LFFTT)   :  F
PLOT OF FFT OF LONGITUDINAL WAKE  (LFFTL)   :  F
PLOT OF INTEGRATION OF IMPEDANCE  (LINTZ)   :  F
PLOT OF ENERGY LOSS SPECTRUM      (LSPEC)   :  F
PLOT OF ELECTRIC FIELD LINES      (LPLE)    :  F
PLOT OF TOTAL CURRENT LINES       (LPLC)    :  F
SWITCH FROM ABSOLUTE TO RELATVE   (LPALL)   :  F
NUMBER OF CONTURE LINES         : NPLOT=      10
CUTOFF FREQUENCY FOR FFT PLOT   :CUTOFF=   5.8436    (GHZ)
WINDOWING FOR FOURIER TRANSFORMS  (LWNDW)   :  T
WINDOW FUNCTION                 : NWFUN=       1
WINDOW PARAMETER FOR WIDTH      : ALPHA=   3.0000

$PRIN:
PRINTOUT OF CAVITY SHAPE USED     (LMATPR)  :  T
PRINTOUT OF WAKE POTENTIALS       (LPRW)    :  F
SAVE WAKE POTENTIALS IN A FILE    (LSVW)    :  F
SAVE AZIMUTHAL WAKE IN A FILE     (LSVWA)   :  F
SAVE TRANSVERSE WAKE IN A FILE    (LSVWT)   :  F
SAVE LONGITUDINAL WAKE IN A FILE  (LSVWL)   :  F
SAVE FFT RESULTS IN A FILE        (LSVF)    :  F
```

CAVITY SHAPE

.=VACUUM ; \,/=TRIANGULAR FILLED MESH CELL ; *=FULL METAL ; B=BEAM

```
************************************************************
******/.............................................\******
******.............................................******
*****/...............................................\*****
****/.................................................\****
****.................................................****
***/...................................................\***
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****\.................................................../****
*****\................................................./*****
******.............................................******
******\............................................./******
*******\............................................/*******
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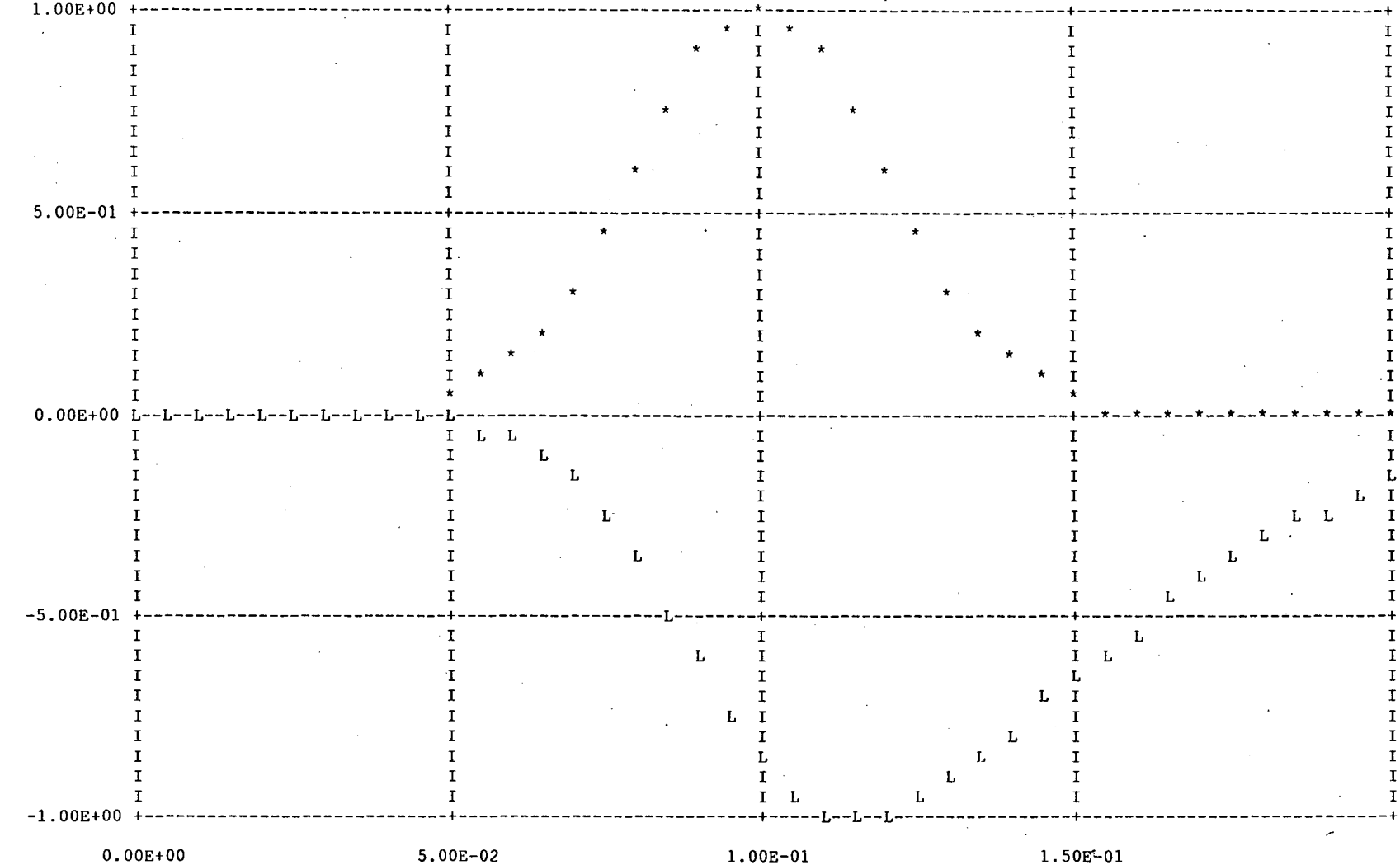
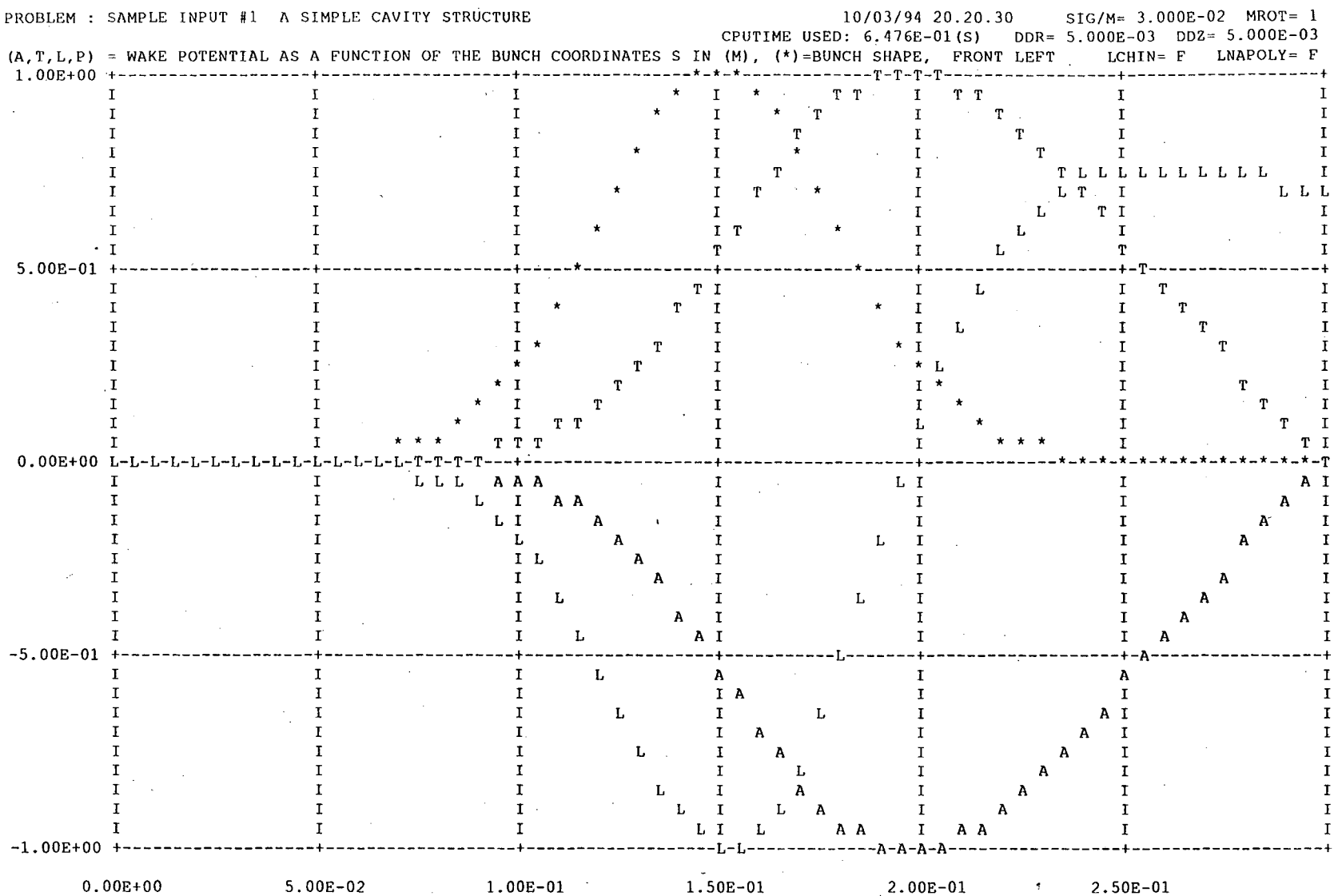
PROBLEM : SAMPLE INPUT #1 A SIMPLE CAVITY STRUCTURE 10/03/94 20.20.30 SIG/M= 2.000E-02 MROT= 0
CPUTIME USED: 2.946E-01(S) DDR= 5.000E-03 DDZ= 5.000E-03
(A,T,L,P) = WAKE POTENTIAL AS A FUNCTION OF THE BUNCH COORDINATES S IN (M), (*)=BUNCH SHAPE, FRONT LEFT LCHIN= F LNAPOLY= F



LINE CHARGE DENSITY MIN/MAX= 7.434E-05/ 1.995E+01 C/M**1, SCALE= 1.995E+01 C/M**1, PASSING AT R= 6.000E-02 M
LONGITUDINAL WAKE MIN/MAX=-3.910E-01/ 0.000E+00 V/PC/M**0, SCALE= 3.910E-01 V/PC/M**0

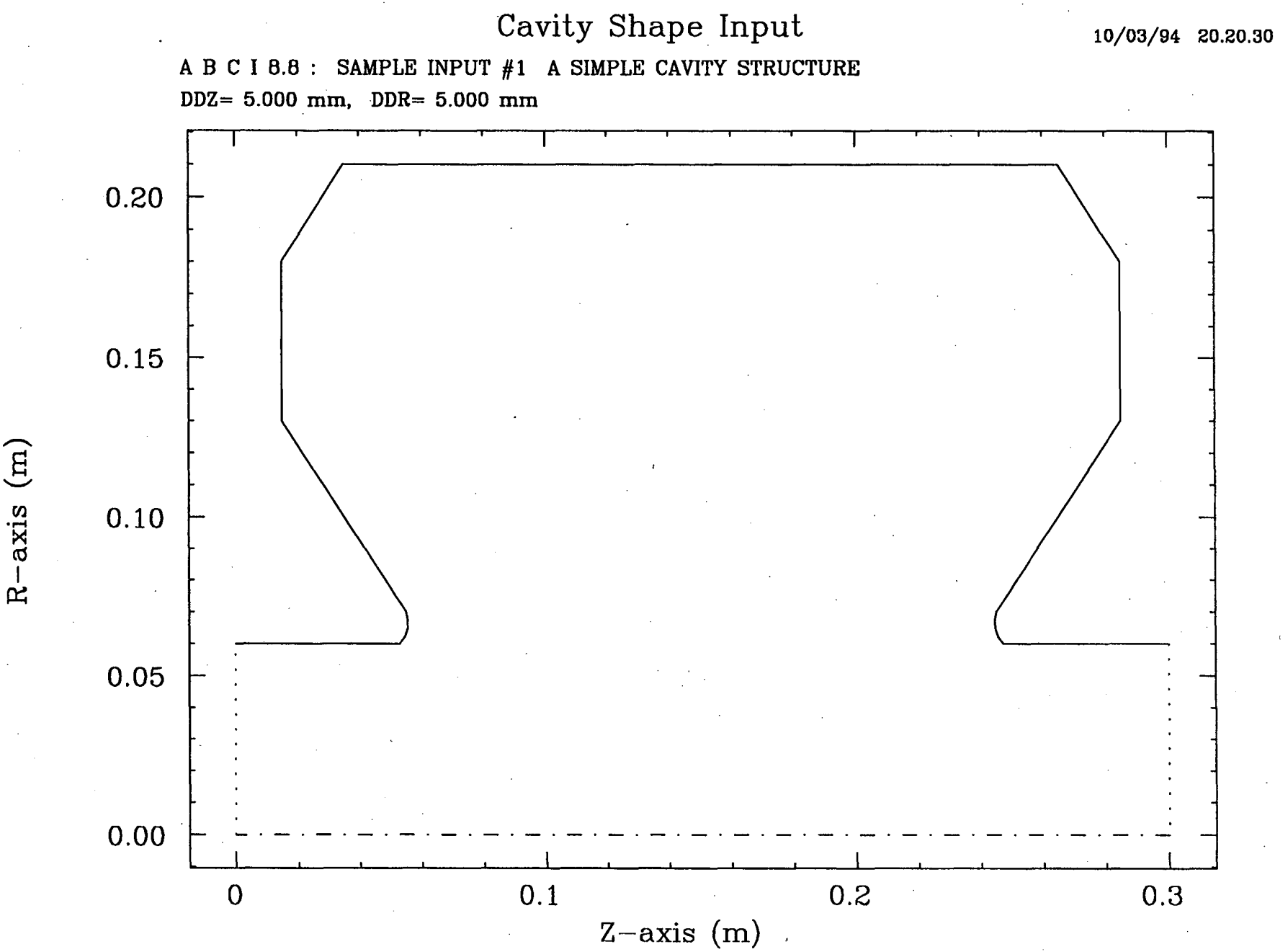
INTEGRATED LONGITUDINAL WAKE * CHARGE DENSITY = -2.785E-01 V/PC/M**0

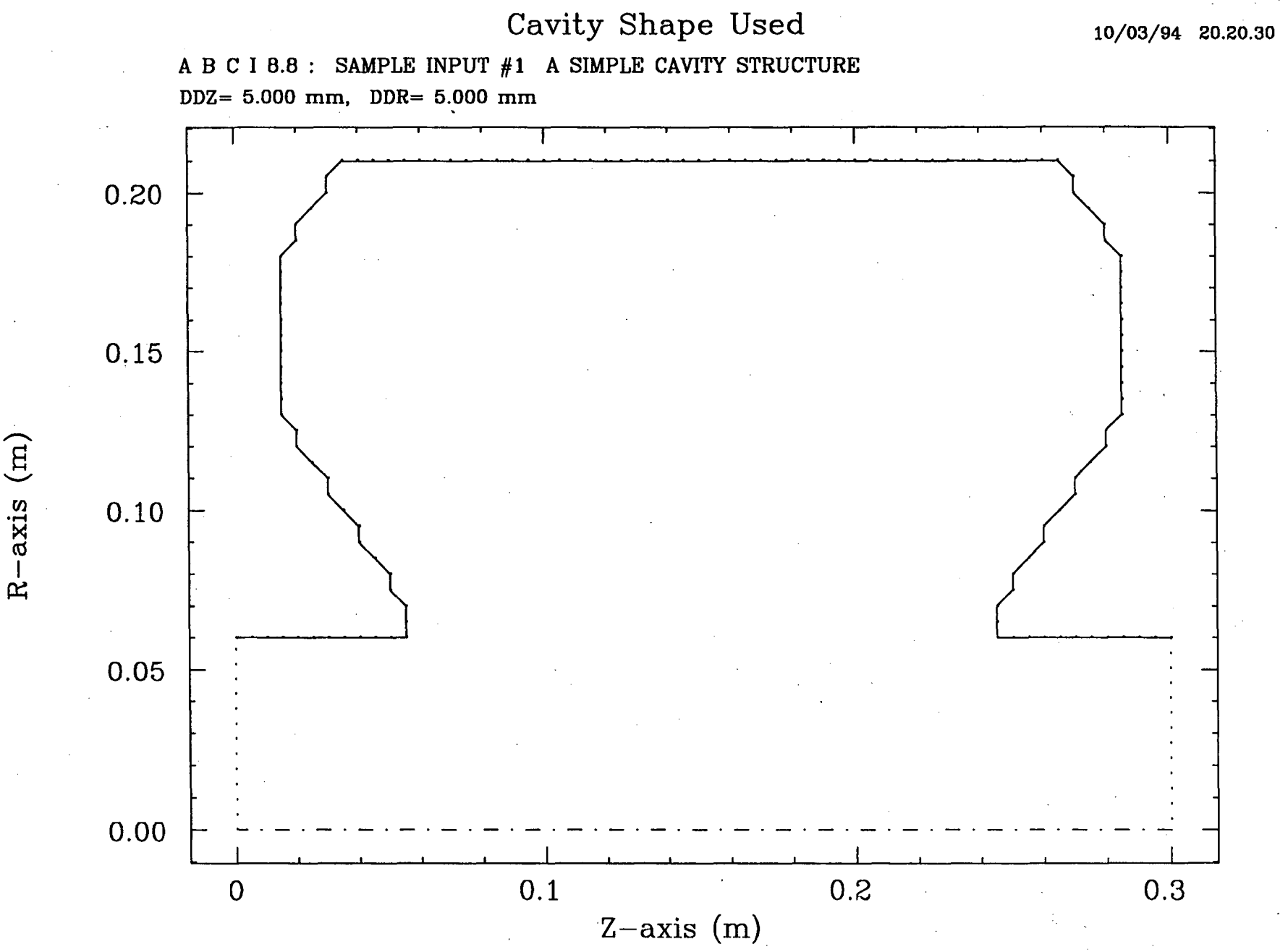
PROBLEM : SAMPLE INPUT #1 A SIMPLE CAVITY STRUCTURE 10/03/94 20.20.30 SIG/M= 3.000E-02 MROT= 1
CPUTIME USED: 6.476E-01(S) DDR= 5.000E-03 DDZ= 5.000E-03
(A,T,L,P) = WAKE POTENTIAL AS A FUNCTION OF THE BUNCH COORDINATES S IN (M), (*)=BUNCH SHAPE, FRONT LEFT LCHIN= F LNAPOLY= F

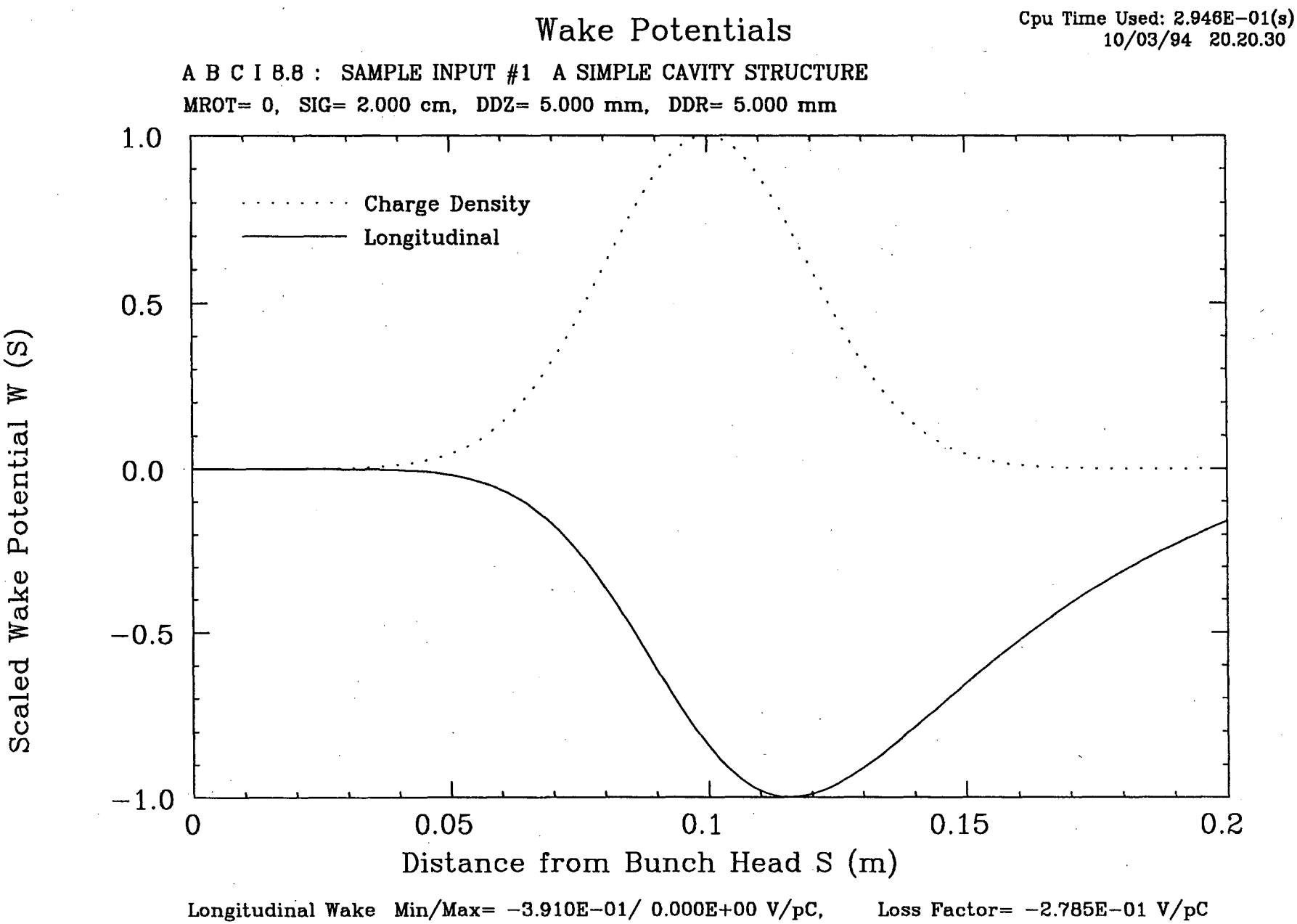


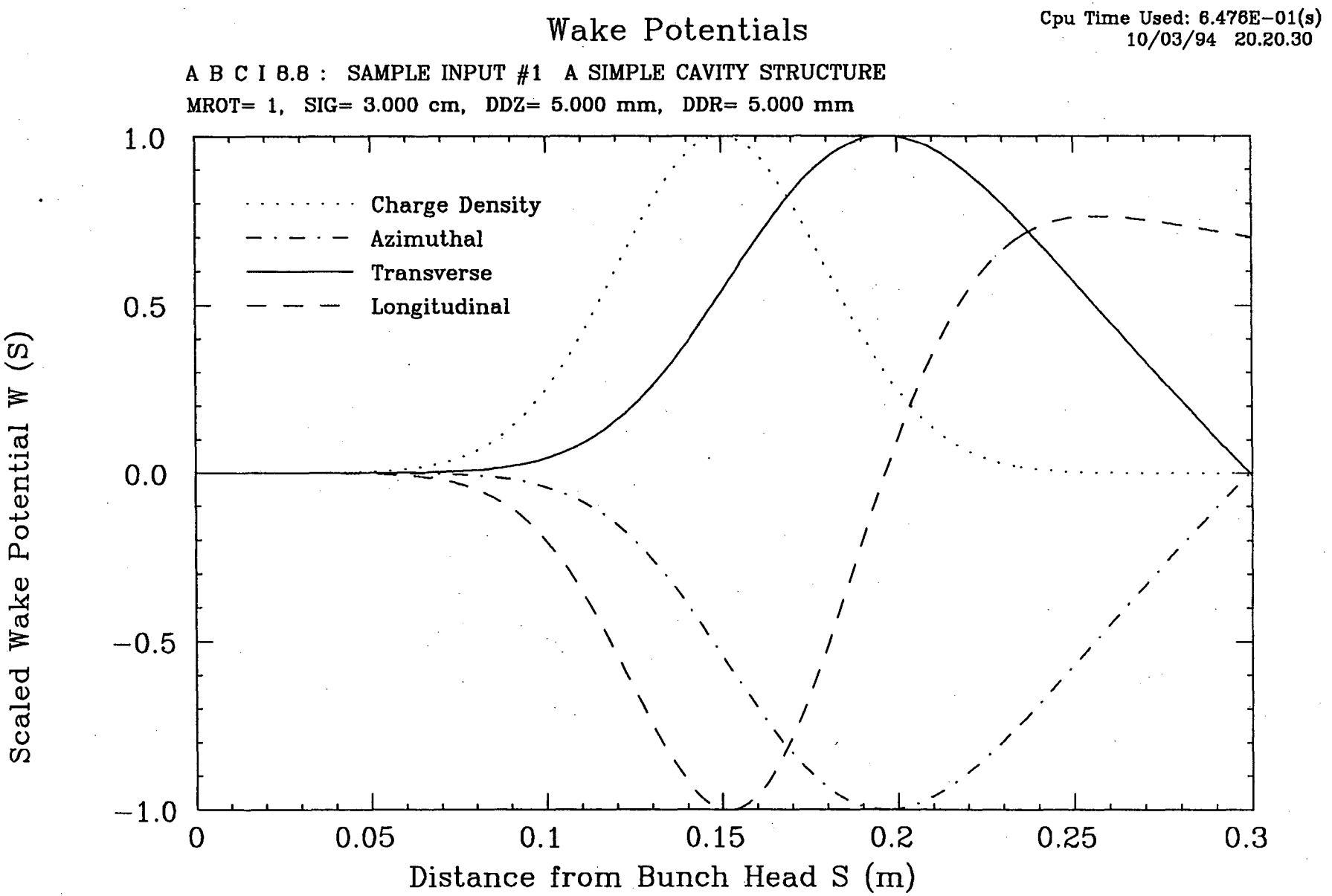
LINE CHARGE DENSITY MIN/MAX= 4.956E-05/ 1.330E+01 C/M**1, SCALE= 1.330E+01 C/M**1, PASSING AT R= 6.000E-02 M
AZIMUTHAL WAKE MIN/MAX=-5.779E+00/ 3.559E-01 V/PC/M**1, SCALE= 5.779E+00 V/PC/M**1, NORMALIZED BY D= 6.000E-02 M DIPOLE OFFSET
TRANSVERSE WAKE MIN/MAX=-4.073E-02/ 5.774E+00 V/PC/M**1, SCALE= 5.774E+00 V/PC/M**1, NORMALIZED BY D= 6.000E-02 M DIPOLE OFFSET
LONGITUDINAL WAKE MIN/MAX=-9.030E+01/ 6.882E+01 V/PC/M**2, SCALE= 9.030E+01 V/PC/M**2, NORMALIZED BY D= 6.000E-02 M DIPOLE OFFSET

INTEGRATED AZIMUTHAL WAKE * CHARGE DENSITY = -3.092E+00 V/PC/M**1
INTEGRATED TRANSVERSE WAKE * CHARGE DENSITY = 3.086E+00 V/PC/M**1
INTEGRATED LONGITUDINAL WAKE * CHARGE DENSITY = -5.767E+01 V/PC/M**2


Cavity Shape Input
10/03/94 20.20.30
A B C I 8.8 : SAMPLE INPUT #1 A SIMPLE CAVITY STRUCTURE
DDZ= 5.000 mm, DDR= 5.000 mm
0.20
0.15
0.10
0.05
0.00
R-axis (m)
0
0.1
0.2
0.3
Z-axis (m)


Cavity Shape Used
10/03/94 20.20.30
A B C I 8.8 : SAMPLE INPUT #1 A SIMPLE CAVITY STRUCTURE
DDZ= 5.000 mm, DDR= 5.000 mm
0.20
0.15
0.10
0.05
0.00
R-axis (m)
0
0.1
0.2
0.3
Z-axis (m)


Wake Potentials
Cpu Time Used: 2.946E-01(s)
10/03/94 20.20.30
A B C I 8.8 : SAMPLE INPUT #1 A SIMPLE CAVITY STRUCTURE
MROT= 0, SIG= 2.000 cm, DDZ= 5.000 mm, DDR= 5.000 mm
Charge Density
Longitudinal
1.0
0.5
0.0
−0.5
−1.0
0
0.05
0.1
0.15
0.2
Scaled Wake Potential W (S)
Distance from Bunch Head S (m)
Longitudinal Wake Min/Max= −3.910E−01/ 0.000E+00 V/pC, Loss Factor= −2.785E−01 V/pC



Azimuthal Wake Min/Max= −5.779E+00/ 3.559E−01 V/pC/m, Loss Factor= −3.092E+00 V/pC/m
Transverse Wake Min/Max= −4.073E−02/ 5.774E+00 V/pC/m, Loss Factor= 3.086E+00 V/pC/m
Longitudinal Wake Min/Max= −9.030E+01/ 6.882E+01 V/pC/m^2, Loss Factor= −5.767E+01 V/pC/m^2

```
*****************************************************************************
*                                                                           *
*                          ABCI   3RD RUN                                   *
*                                                                           *
*   DATE:10/03/94   TIME:20.20.32     VERSION 8.8,  FEBRUARY  1994          *
*                                                                           *
*****************************************************************************


$FILE:
SAVE FIELDS INTO FILE  (LSAV)   :  F
RECOVER FROM FILE      (LREC)   :  F
CPUTIME MONITOR ACTIVE (LCPUTM):  F

$BOUN:
BOUNDARY CONDITIONS     LEFT   : OPEN
BOUNDARY CONDITIONS     RIGHT  : OPEN

$MESH:
NUMBER OF MESH LINES IN R       : NR   =      37
NUMBER OF MESH LINES IN Z       : NZ   =      60
NUMBER OF MESH POINTS           : NP   =    2220
TOTAL RADIUS OF THE STRUCTURE   : RAD  =  0.21000     (M)
TOTAL LENGTH OF THE STRUCTURE   : ZL   =  0.30000     (M)
STEP SIZE IN R                  : DDR  =  0.50000E-02(M)  FROM R=  0.00000E+00  TO R=  0.70000E-01
STEP SIZE IN R                  : DDR  =  0.75000E-02(M)  FROM R=  0.70000E-01  TO R=  0.13000
STEP SIZE IN R                  : DDR  =  0.50000E-02(M)  FROM R=  0.13000      TO R=  0.18000
STEP SIZE IN R                  : DDR  =  0.75000E-02(M)  FROM R=  0.18000      TO R=  0.21000
STEP SIZE IN Z                  : DDZ  =  0.50000E-02(M)

#CAVITYSHAPE (##CAVITYSHAPE) :  HALF CELL INPUT

INPUT:        (R, Z)                    (IR, IZ)
(   0.00000E+00  0.00000E+00 )  (       1      1 )
(   0.21000      0.00000E+00 )  (      37      1 )
(   0.21000      0.11500     )  (      37     24 )
(   0.18000      0.13500     )  (      33     28 )
(   0.13000      0.13500     )  (      23     28 )
(   0.70000E-01  0.95000E-01 )  (      15     20 )
CONNECTED BY A CONCAVE CIRCLE, IKIND=-1,  RADIUS=  0.90000E-02
(   0.60000E-01  0.97000E-01 )  (      13     20 ) ---> (   0.60000E-01  0.95000E-01 )
(   0.60000E-01  0.15000     )  (      13     30 )
(   0.00000E+00  0.15000     )  (       1     31 )
(   0.00000E+00  0.00000E+00 )  (       1      1 )

$BEAM:
SIGMA OF THE GAUSSIAN BUNCH     : SIG  =  0.20000E-01(M)
NUMBER OF STAND.DEV. USED       : ISIG = +/-  5
RADIAL BEAM OFFSET AT           :RDRIVE=  0.60000E-01(M)
MODE NUMBER (MONOPOLE/DIPOLE)   : MROT =      0

$WAKE:
RADIAL WAKE OFFSET        (LEFT)   AT  R   =  0.60000E-01(M)
WAKE    BETWEEN THE BUNCH  COORDINATES UBF =  0.00000E+00(M)
                                     AND UBT =   8.0000     (M)
WINDOW FOR FRONT                  (LCFRON)  :  T
WINDOW FOR BACK                   (LCBACK)  :  T
CHIN WAKE INTEGRATION METHOD      (LCHIN )  :  F
NAPOLY WAKE INTEGRATION METHOD    (LNAPOLY) :  F
NUMBER OF WAKE POTENTIAL POINTS: NW   =    1601
```

```
$TIME:
TIME STEPS TO BE PROCESSED      : NT   =   4984
NUMBER OF TIME STEPS/MESH STEP  : MT   =      3
VELOCITY OF THE BUNCH / C       : BETA =   1.0000
TIME-STEP VALUE                 : DT   =   5.5594    (PS)
TIME FOR A PARTICLE TO PASS     : PT   =   1000.7    (PS)

$PLOT:
PLOT OF CAVITY SHAPE INPUT        (LCAVIN)  :  F
PLOT OF CAVITY SHAPE USED         (LCAVUS)  :  T
PLOT OF ALL WAKE POTENTIALS       (LPLW)    :  T
PLOT OF AZIMUTHAL WAKE POTENTIAL  (LPLWA)   :  F
PLOT OF TRANSVERSE WAKE POTENT.   (LPLWT)   :  F
PLOT OF LONGITUDINAL WAKE POTENT. (LPLWL)   :  F
PLOT OF FFT OF WAKE POTENTIALS    (LFFT)    :  F
PLOT OF FFT OF AZIMUTHAL WAKE     (LFFTA)   :  F
PLOT OF FFT OF TRANSVERSE WAKE    (LFFTT)   :  F
PLOT OF FFT OF LONGITUDINAL WAKE  (LFFTL)   :  T
PLOT OF INTEGRATION OF IMPEDANCE  (LINTZ)   :  F
PLOT OF ENERGY LOSS SPECTRUM      (LSPEC)   :  T
PLOT OF ELECTRIC FIELD LINES      (LPLE)    :  F
PLOT OF TOTAL CURRENT LINES       (LPLC)    :  F
SWITCH FROM ABSOLUTE TO RELATVE   (LPALL)   :  F
NUMBER OF CONTURE LINES         : NPLOT=      10
CUTOFF FREQUENCY FOR FFT PLOT   :CUTOFF=   3.8957    (GHZ)
WINDOWING FOR FOURIER TRANSFORMS  (LWNDW)   :  T
WINDOW FUNCTION                 : NWFUN=       1
WINDOW PARAMETER FOR WIDTH      : ALPHA=   3.0000

$PRIN:
PRINTOUT OF CAVITY SHAPE USED     (LMATPR)  :  T
PRINTOUT OF WAKE POTENTIALS       (LPRW)    :  F
SAVE WAKE POTENTIALS IN A FILE    (LSVW)    :  F
SAVE AZIMUTHAL WAKE IN A FILE     (LSVWA)   :  F
SAVE TRANSVERSE WAKE IN A FILE    (LSVWT)   :  F
SAVE LONGITUDINAL WAKE IN A FILE  (LSVWL)   :  F
SAVE FFT RESULTS IN A FILE        (LSVF)    :  F
```

CAVITY SHAPE
.=VACUUM ; \,/=TRIANGULAR FILLED MESH CELL ; *=FULL METAL ; B=BEAM

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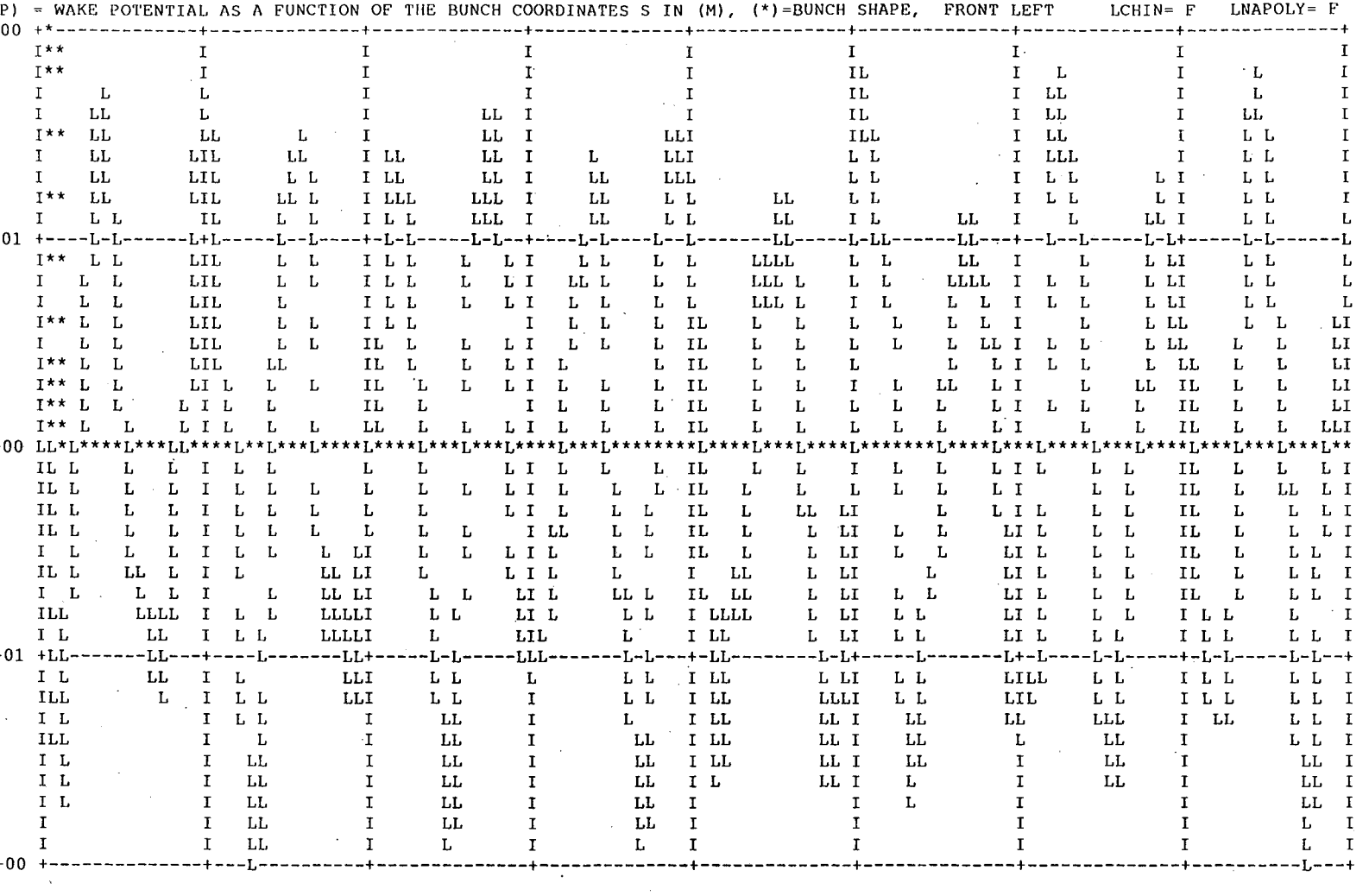
PROBLEM : SAMPLE INPUT #1 A SIMPLE CAVITY STRUCTURE 10/03/94 20.20.32 SIG/M= 2.000E-02 MROT= 0

CPUTIME USED: 5.767E+00(S) DDR= 5.000E-03 DDZ= 5.000E-03

(A,T,L,P) = WAKE POTENTIAL AS A FUNCTION OF THE BUNCH COORDINATES S IN (M), (*)=BUNCH SHAPE, FRONT LEFT LCHIN= F LNAPOLY= F



LINE CHARGE DENSITY MIN/MAX= 0.000E+00/ 1.995E+01 C/M**1, SCALE= 1.995E+01 C/M**1, PASSING AT R= 6.000E-02 M

LONGITUDINAL WAKE MIN/MAX=-4.786E-01/ 4.362E-01 V/PC/M**0, SCALE= 4.786E-01 V/PC/M**0

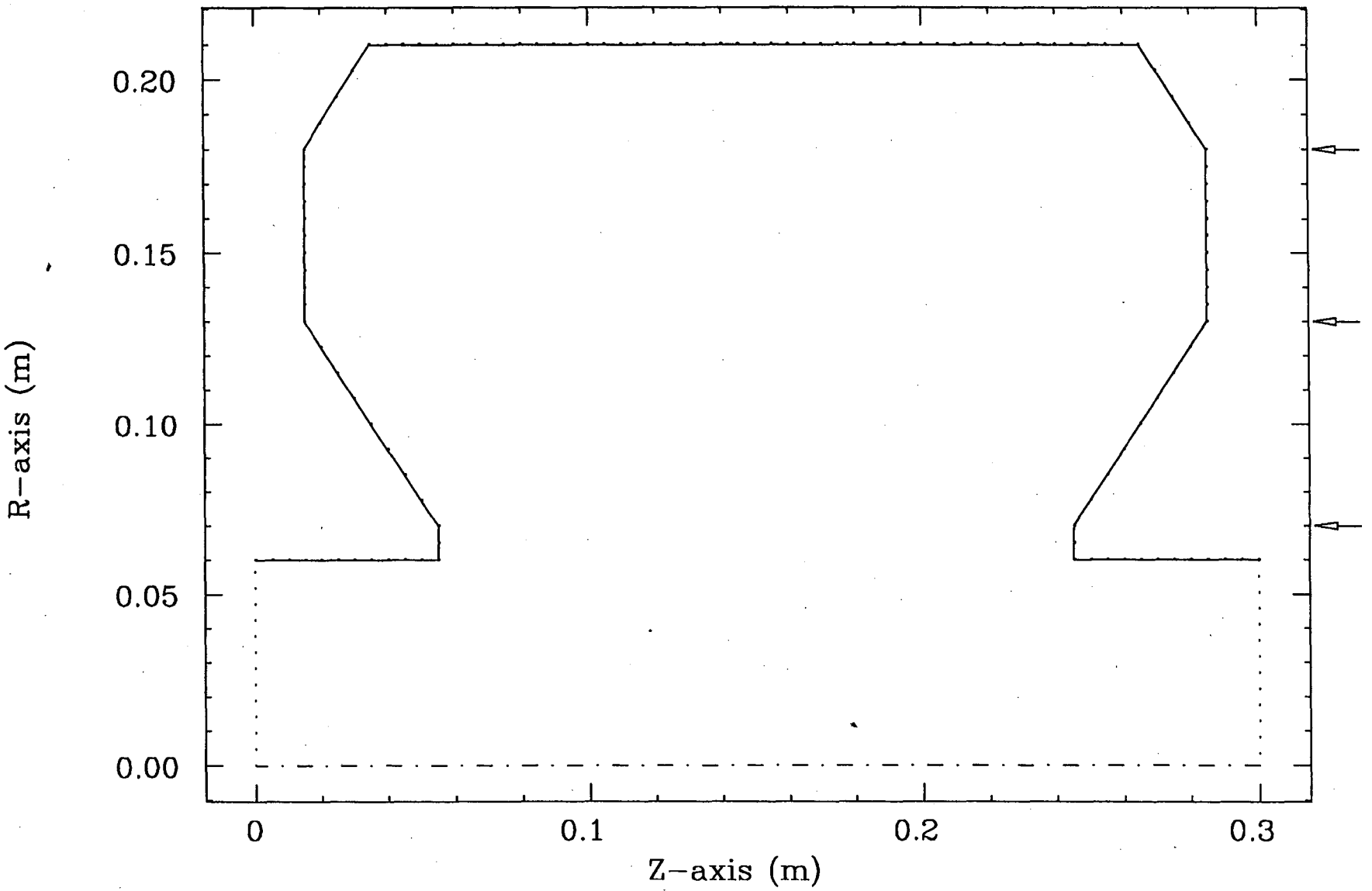
INTEGRATED LONGITUDINAL WAKE * CHARGE DENSITY = -2.821E-01 V/PC/M**0

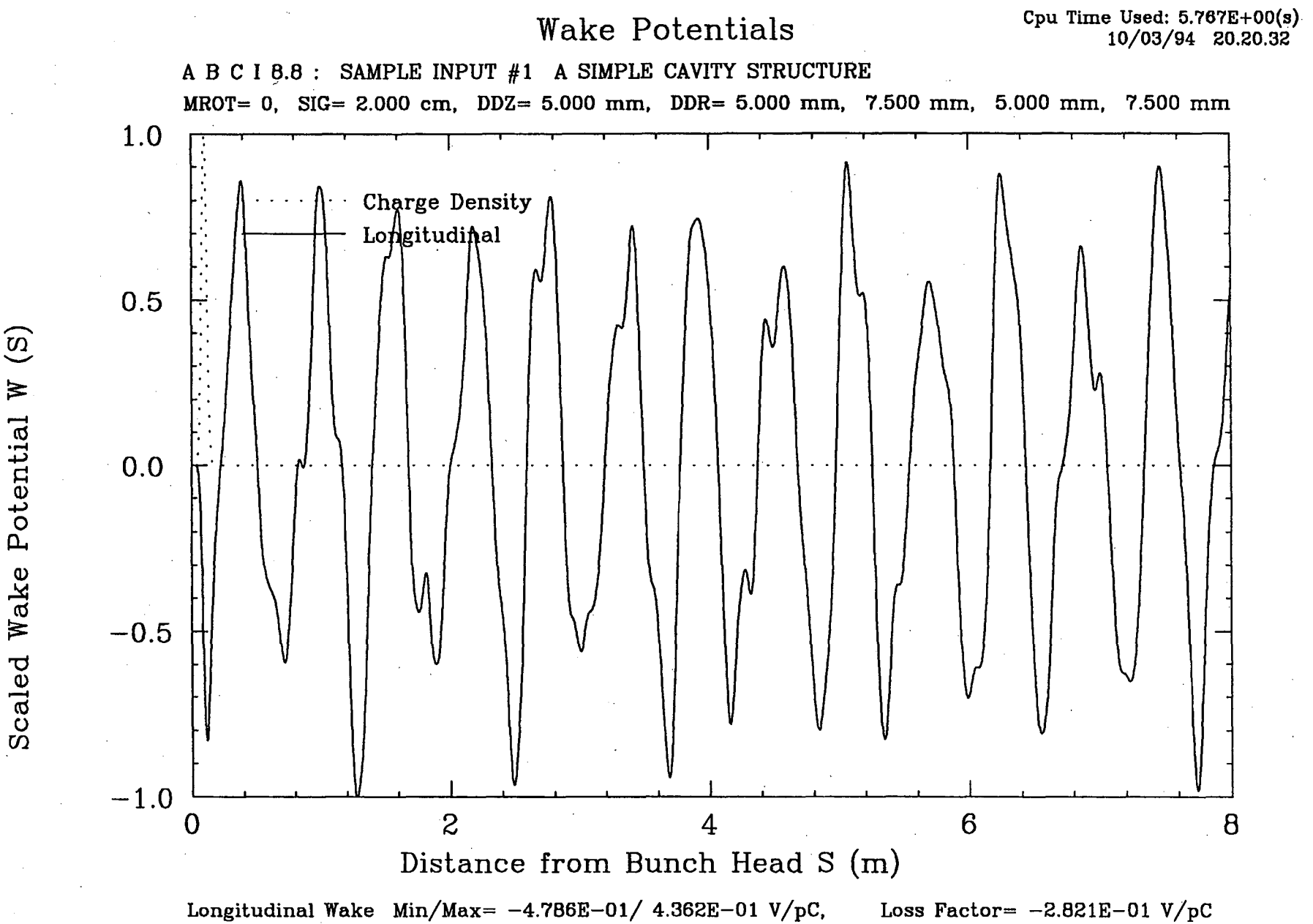
Cavity Shape Used

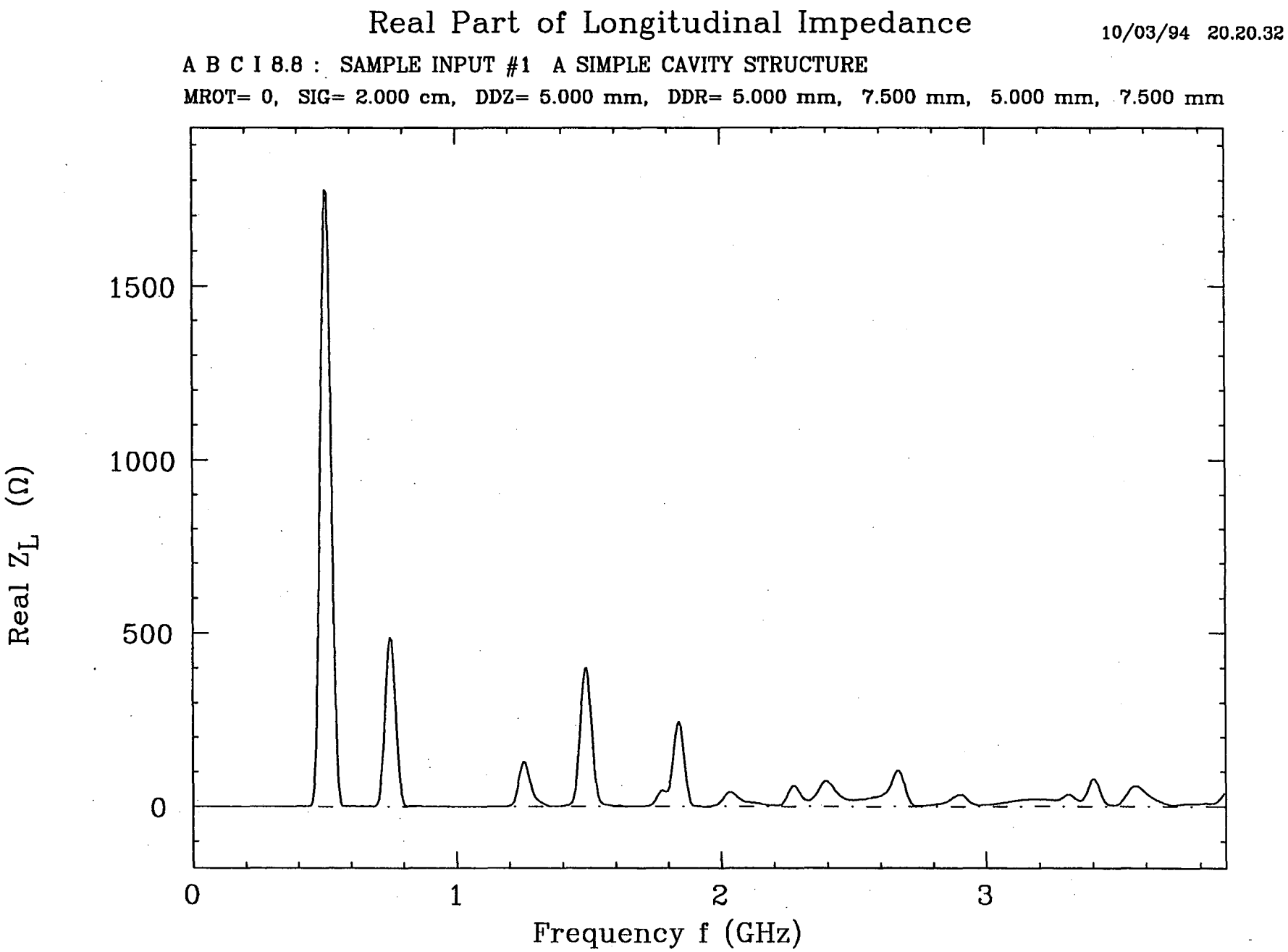
10/03/94 20.20.32

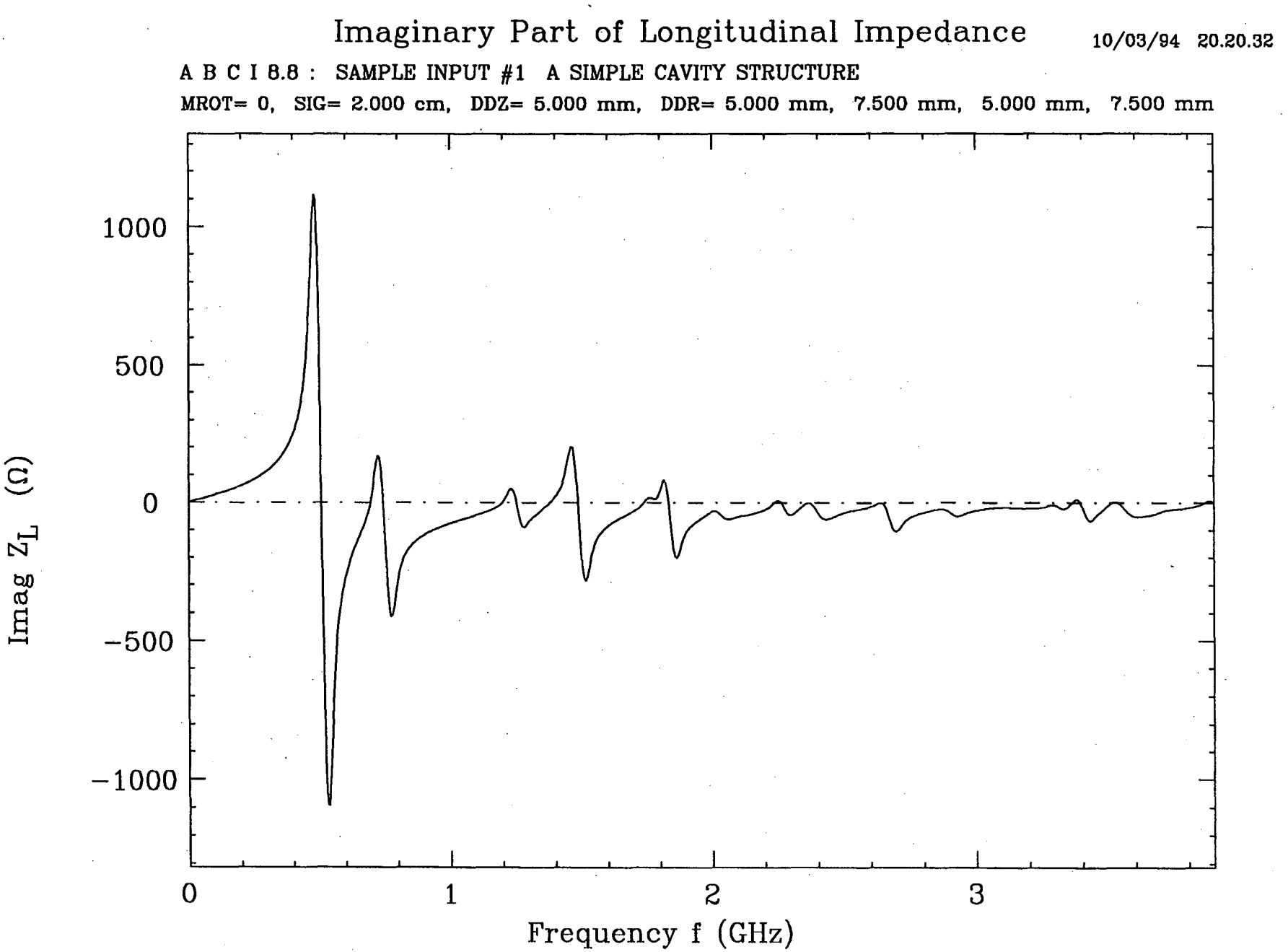
A B C I 8.8 : SAMPLE INPUT #1 A SIMPLE CAVITY STRUCTURE

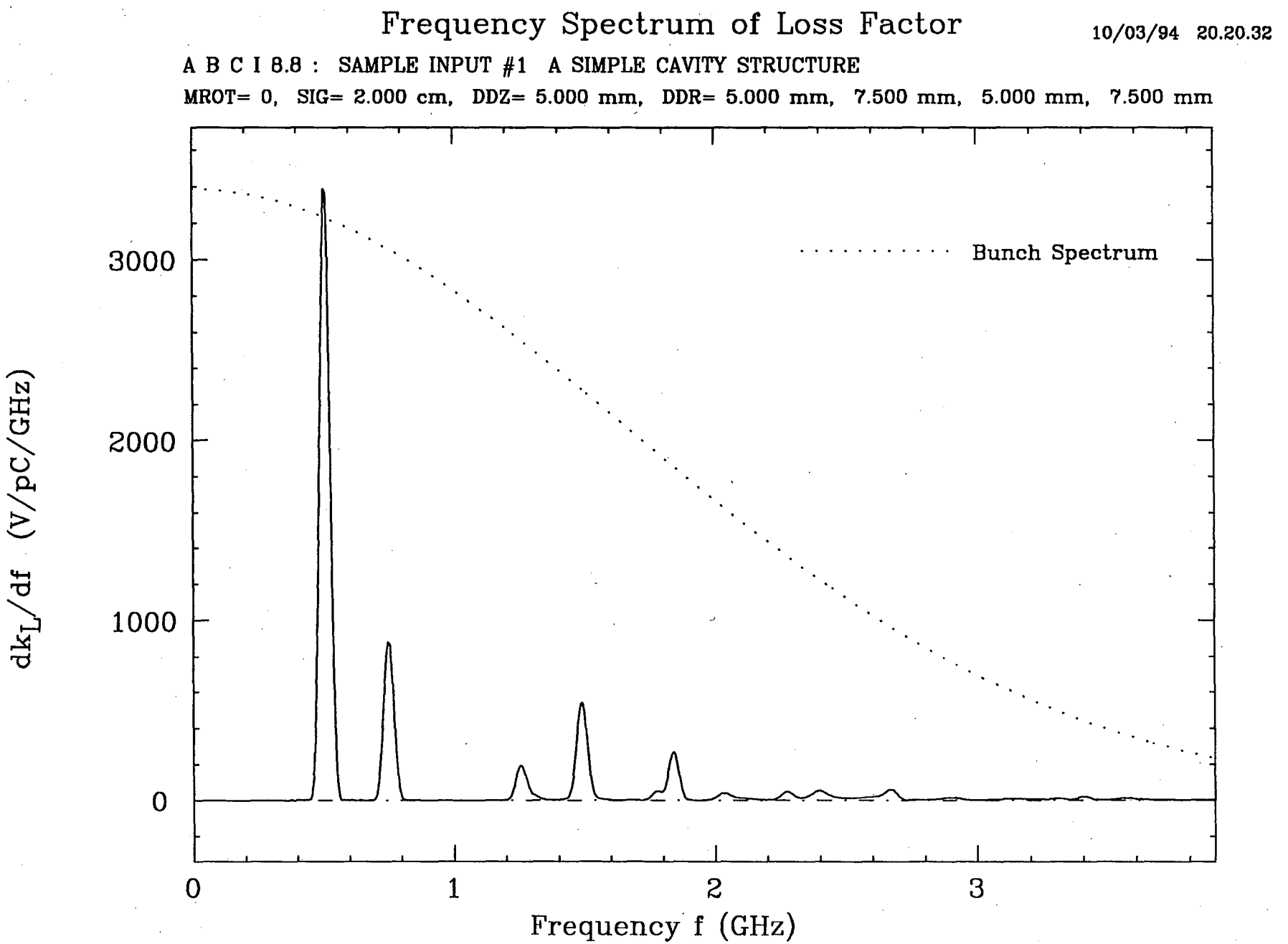
DDZ= 5.000 mm, DDR= 5.000 mm, 7.500 mm, 5.000 mm, 7.500 mm

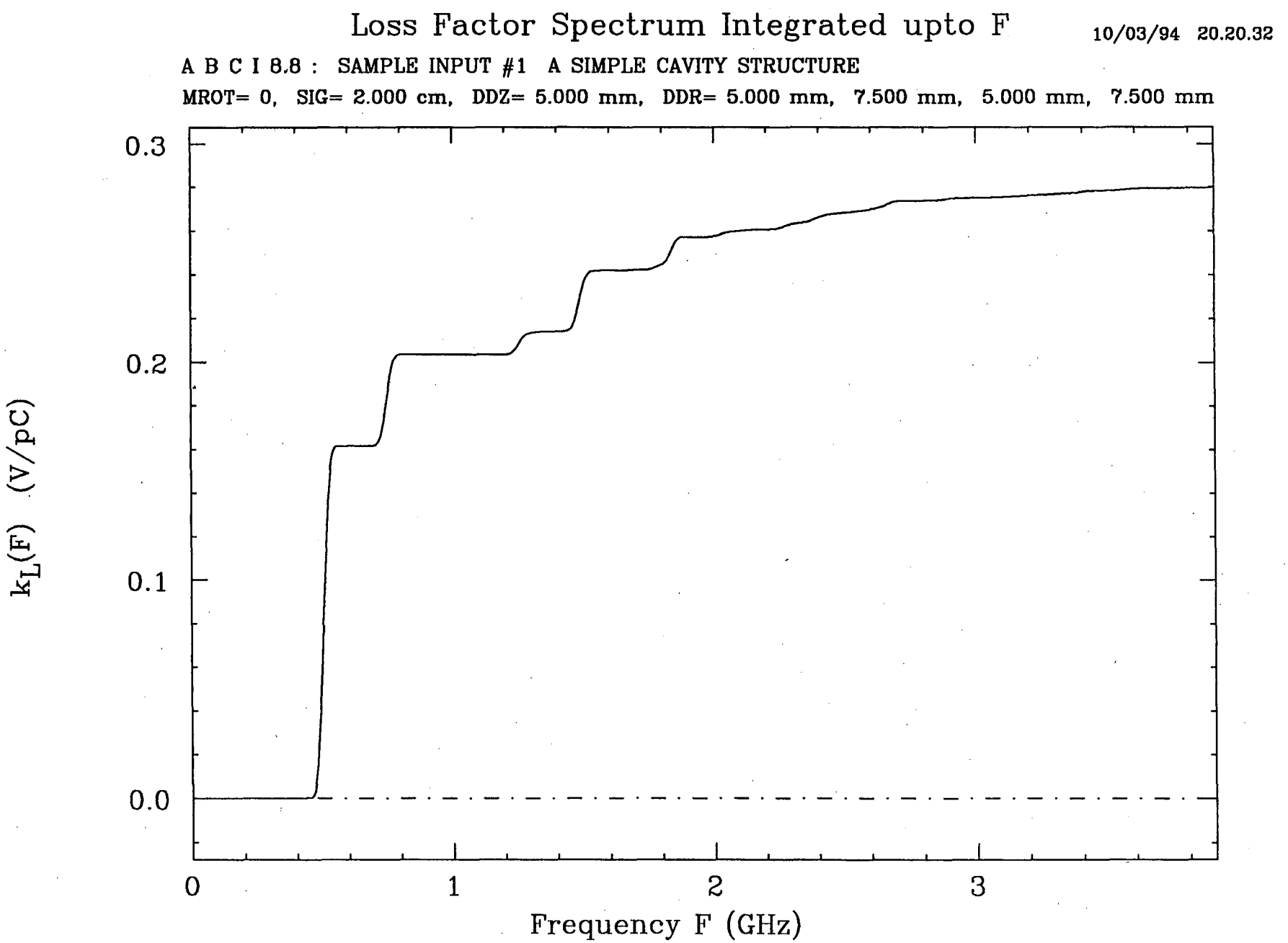



Wake Potentials
Cpu Time Used: 5.767E+00(s)
10/03/94 20.20.32
A B C I 8.8 : SAMPLE INPUT #1 A SIMPLE CAVITY STRUCTURE
MROT= 0, SIG= 2.000 cm, DDZ= 5.000 mm, DDR= 5.000 mm, 7.500 mm, 5.000 mm, 7.500 mm
Charge Density
Longitudinal
Scaled Wake Potential W (S)
1.0
0.5
0.0
−0.5
−1.0
0
2
4
6
8
Distance from Bunch Head S (m)
Longitudinal Wake Min/Max= −4.786E−01/ 4.362E−01 V/pC, Loss Factor= −2.821E−01 V/pC


Real Part of Longitudinal Impedance
10/03/94 20.20.32
A B C I 8.8 : SAMPLE INPUT #1 A SIMPLE CAVITY STRUCTURE
MROT= 0, SIG= 2.000 cm, DDZ= 5.000 mm, DDR= 5.000 mm, 7.500 mm, 5.000 mm, 7.500 mm
Real Z_L (Ω)
1500
1000
500
0
0
1
2
3
Frequency f (GHz)


Imaginary Part of Longitudinal Impedance
10/03/94 20.20.32
A B C I 8.8 : SAMPLE INPUT #1 A SIMPLE CAVITY STRUCTURE
MROT= 0, SIG= 2.000 cm, DDZ= 5.000 mm, DDR= 5.000 mm, 7.500 mm, 5.000 mm, 7.500 mm
1000
500
0
−500
−1000
Imag Z_L (Ω)
0
1
2
3
Frequency f (GHz)


Frequency Spectrum of Loss Factor
10/03/94 20.20.32
A B C I 8.8 : SAMPLE INPUT #1 A SIMPLE CAVITY STRUCTURE
MROT= 0, SIG= 2.000 cm, DDZ= 5.000 mm, DDR= 5.000 mm, 7.500 mm, 5.000 mm, 7.500 mm
Bunch Spectrum
3000
2000
1000
0
dk_L/df (V/pC/GHz)
0
1
2
3
Frequency f (GHz)


Loss Factor Spectrum Integrated upto F
10/03/94 20.20.32
A B C I 8.8 : SAMPLE INPUT #1 A SIMPLE CAVITY STRUCTURE
MROT= 0, SIG= 2.000 cm, DDZ= 5.000 mm, DDR= 5.000 mm, 7.500 mm, 5.000 mm, 7.500 mm
0.3
0.2
0.1
0.0
$k_L(F)$ (V/pC)
0
1
2
3
Frequency F (GHz)

```
*************************************************************************
*                                                                       *
*                                ABCI                                   *
*                                                                       *
* Azimuthal Beam Cavity Interaction in a cylindrically symmetric structure *
*                                                                       *
*  SAMPLE INPUT #2  A COLLIMATOR-LIKE STRUCTURE WITH DOUBLE TEETH       *
*                                                                       *
*     DATE:10/03/94   TIME:20.26.18     VERSION 8.8,  FEBRUARY  1994    *
*                                                                       *
*************************************************************************


$FILE:
SAVE FIELDS INTO FILE  (LSAV)   :  F
RECOVER FROM FILE      (LREC)   :  F
CPUTIME MONITOR ACTIVE (LCPUTM):  F

$BOUN:
BOUNDARY CONDITIONS     LEFT   : OPEN
BOUNDARY CONDITIONS     RIGHT  : OPEN

$MESH:
NUMBER OF MESH LINES IN R       : NR   =      31
NUMBER OF MESH LINES IN Z       : NZ   =      80
NUMBER OF MESH POINTS           : NP   =    2480
TOTAL RADIUS OF THE STRUCTURE   : RAD  =  0.60000E-01(M)
TOTAL LENGTH OF THE STRUCTURE   : ZL   =  0.16000    (M)
STEP SIZE IN R                  : DDR  =  0.20000E-02(M)
STEP SIZE IN Z                  : DDZ  =  0.20000E-02(M)
STRUCTURE INPUT VARIABLE        : RZ  1=  0.10000E-01(M)
STRUCTURE INPUT VARIABLE        : RZ  2=  0.30000E-01(M)

@CAVITYSHAPE (@@CAVITYSHAPE) :  FULL CELL INPUT

INPUT:        (R, Z)                    (IR, IZ)
(   0.00000E+00  0.00000E+00 )  (       1       1 ) ---> (   0.00000E+00  0.00000E+00 )
(   0.30000E-01  0.00000E+00 )  (      16       1 ) ---> (   0.30000E-01  0.00000E+00 )
(   0.00000E+00  0.30000E-01 )  (      16      16 ) ---> (   0.30000E-01  0.30000E-01 )
(   0.10000E-01  0.00000E+00 )  (      21      16 ) ---> (   0.40000E-01  0.30000E-01 )
CONNECTED BY AN ELLIPSE,       IKIND=-3,  (RM, ZM)=      (   0.40000E-01  0.40000E-01 )
(   0.20000E-01  0.00000E+00 )  (      31      21 ) ---> (   0.60000E-01  0.40000E-01 )
CONNECTED BY AN ELLIPSE,       IKIND=-3,  (RM, ZM)=      (   0.40000E-01  0.40000E-01 )
(   0.00000E+00  0.10000E-01 )  (      21      26 ) ---> (   0.40000E-01  0.50000E-01 )
(  -0.20000E-01  0.00000E+00 )  (      11      26 ) ---> (   0.20000E-01  0.50000E-01 )
CONNECTED BY A CONCAVE CIRCLE, IKIND=-1,  RADIUS=  0.10000E-01
(   0.00000E+00  0.20000E-01 )  (      11      36 ) ---> (   0.20000E-01  0.70000E-01 )
(   0.20000E-01  0.00000E+00 )  (      21      36 ) ---> (   0.40000E-01  0.70000E-01 )
CONNECTED BY AN ELLIPSE,       IKIND=-3,  (RM, ZM)=      (   0.40000E-01  0.80000E-01 )
(   0.20000E-01  0.00000E+00 )  (      31      41 ) ---> (   0.60000E-01  0.80000E-01 )
CONNECTED BY AN ELLIPSE,       IKIND=-3,  (RM, ZM)=      (   0.40000E-01  0.80000E-01 )
(   0.00000E+00  0.10000E-01 )  (      21      46 ) ---> (   0.40000E-01  0.90000E-01 )
(  -0.20000E-01  0.00000E+00 )  (      11      46 ) ---> (   0.20000E-01  0.90000E-01 )
CONNECTED BY A CONCAVE CIRCLE, IKIND=-1,  RADIUS=  0.10000E-01
(   0.00000E+00  0.20000E-01 )  (      11      56 ) ---> (   0.20000E-01  0.11000      )
(   0.20000E-01  0.00000E+00 )  (      21      56 ) ---> (   0.40000E-01  0.11000      )
CONNECTED BY AN ELLIPSE,       IKIND=-3,  (RM, ZM)=      (   0.40000E-01  0.12000      )
(   0.20000E-01  0.00000E+00 )  (      31      61 ) ---> (   0.60000E-01  0.12000      )
CONNECTED BY AN ELLIPSE,       IKIND=-3,  (RM, ZM)=      (   0.40000E-01  0.12000      )
```

Figure 7: Output for the sample input # 2.

```
(   0.00000E+00  0.10000E-01 )  (      21      66 ) ---> (   0.40000E-01  0.13000      )
(     -RZ  1     0.00000E+00 )  (      16      66 ) ---> (   0.30000E-01  0.13000      )
(   0.00000E+00  0.30000E-01 )  (      16      80 ) ---> (   0.30000E-01  0.16000      )
(     -RZ  2     0.00000E+00 )  (       1      81 ) ---> (   0.00000E+00  0.16000      )
(   0.00000E+00 -0.16000     )  (       1       1 ) ---> (   0.00000E+00  0.00000E+00 )

$BEAM:
SIGMA OF THE GAUSSIAN BUNCH     : SIG  =  0.20000E-01(M)
NUMBER OF STAND.DEV. USED       : ISIG = +/-  5
RADIAL BEAM OFFSET AT           :RDRIVE=  0.10000E-01(M)
MODE NUMBER (MONOPOLE/DIPOLE)   : MROT =      0

$WAKE:
RADIAL WAKE OFFSET        (LEFT)   AT  R   =  0.30000E-01(M)
WAKE    BETWEEN THE BUNCH  COORDINATES UBF =  0.00000E+00(M)
                                     AND UBT =  0.20000     (M)
WINDOW FOR FRONT                  (LCFRON)  :  T
WINDOW FOR BACK                   (LCBACK)  :  T
CHIN WAKE INTEGRATION METHOD      (LCHIN )  :  F
NAPOLY WAKE INTEGRATION METHOD    (LNAPOLY) :  T
NUMBER OF WAKE POTENTIAL POINTS: NW   =     101

$TIME:
TIME STEPS TO BE PROCESSED      : NT   =    544
NUMBER OF TIME STEPS/MESH STEP  : MT   =      3
VELOCITY OF THE BUNCH / C       : BETA =   1.0000
TIME-STEP VALUE                 : DT   =   2.2238    (PS)
TIME FOR A PARTICLE TO PASS     : PT   =   533.70    (PS)

$PLOT:
PLOT OF CAVITY SHAPE INPUT        (LCAVIN)  :  T
PLOT OF CAVITY SHAPE USED         (LCAVUS)  :  T
PLOT OF ALL WAKE POTENTIALS       (LPLW)    :  T
PLOT OF AZIMUTHAL WAKE POTENTIAL  (LPLWA)   :  F
PLOT OF TRANSVERSE WAKE POTENT.   (LPLWT)   :  F
PLOT OF LONGITUDINAL WAKE POTENT. (LPLWL)   :  F
PLOT OF FFT OF WAKE POTENTIALS    (LFFT)    :  F
PLOT OF FFT OF AZIMUTHAL WAKE     (LFFTA)   :  F
PLOT OF FFT OF TRANSVERSE WAKE    (LFFTT)   :  F
PLOT OF FFT OF LONGITUDINAL WAKE  (LFFTL)   :  F
PLOT OF INTEGRATION OF IMPEDANCE  (LINTZ)   :  F
PLOT OF ENERGY LOSS SPECTRUM      (LSPEC)   :  F
PLOT OF ELECTRIC FIELD LINES      (LPLE)    :  F
PLOT OF TOTAL CURRENT LINES       (LPLC)    :  F
SWITCH FROM ABSOLUTE TO RELATVE   (LPALL)   :  F
NUMBER OF CONTURE LINES         : NPLOT=      10
CUTOFF FREQUENCY FOR FFT PLOT   :CUTOFF=   5.8436    (GHZ)
WINDOWING FOR FOURIER TRANSFORMS (LWNDW)    :  T
WINDOW FUNCTION                 : NWFUN=       1
WINDOW PARAMETER FOR WIDTH      : ALPHA=   3.0000

$PRIN:
PRINTOUT OF CAVITY SHAPE USED     (LMATPR)  :  T
PRINTOUT OF WAKE POTENTIALS       (LPRW)    :  F
SAVE WAKE POTENTIALS IN A FILE    (LSVW)    :  F
SAVE AZIMUTHAL WAKE IN A FILE     (LSVWA)   :  F
SAVE TRANSVERSE WAKE IN A FILE    (LSVWT)   :  F
SAVE LONGITUDINAL WAKE IN A FILE  (LSVWL)   :  F
SAVE FFT RESULTS IN A FILE        (LSVF)    :  F
*** WARNING *** YOU DID NOT FULLY SPECIFY THE INTEGRATION CONTURE DESPITE OF LNAPOLY=T.
```

```
*** ABCI CHOOSES THE FOLLOWING CONTURE: ***
ZCF=  0.46000E-01(M)     ZCT=  0.11400     (M)     AND RWAK=  0.10000E-01(M)
YOU SHOULD STILL CHECK IF THIS CONTURE IS VALID OR NOT.

*** CAUTION *** YOU MUST NOW USE NAPOLY INTEGRATION FOR CALCULATION OF THE WAKE POTENTIALS.
YOUR CASE: LNAPOLY= T
IF LNAPOLY=F, ABCI NOW CHANGES IT TO LNAPOLY=T.
CHECK IF THE CONTURE IS VALID.
```

CAVITY SHAPE
.=VACUUM ; \,/=TRIANGULAR FILLED MESH CELL ; *=FULL METAL ; B=BEAM

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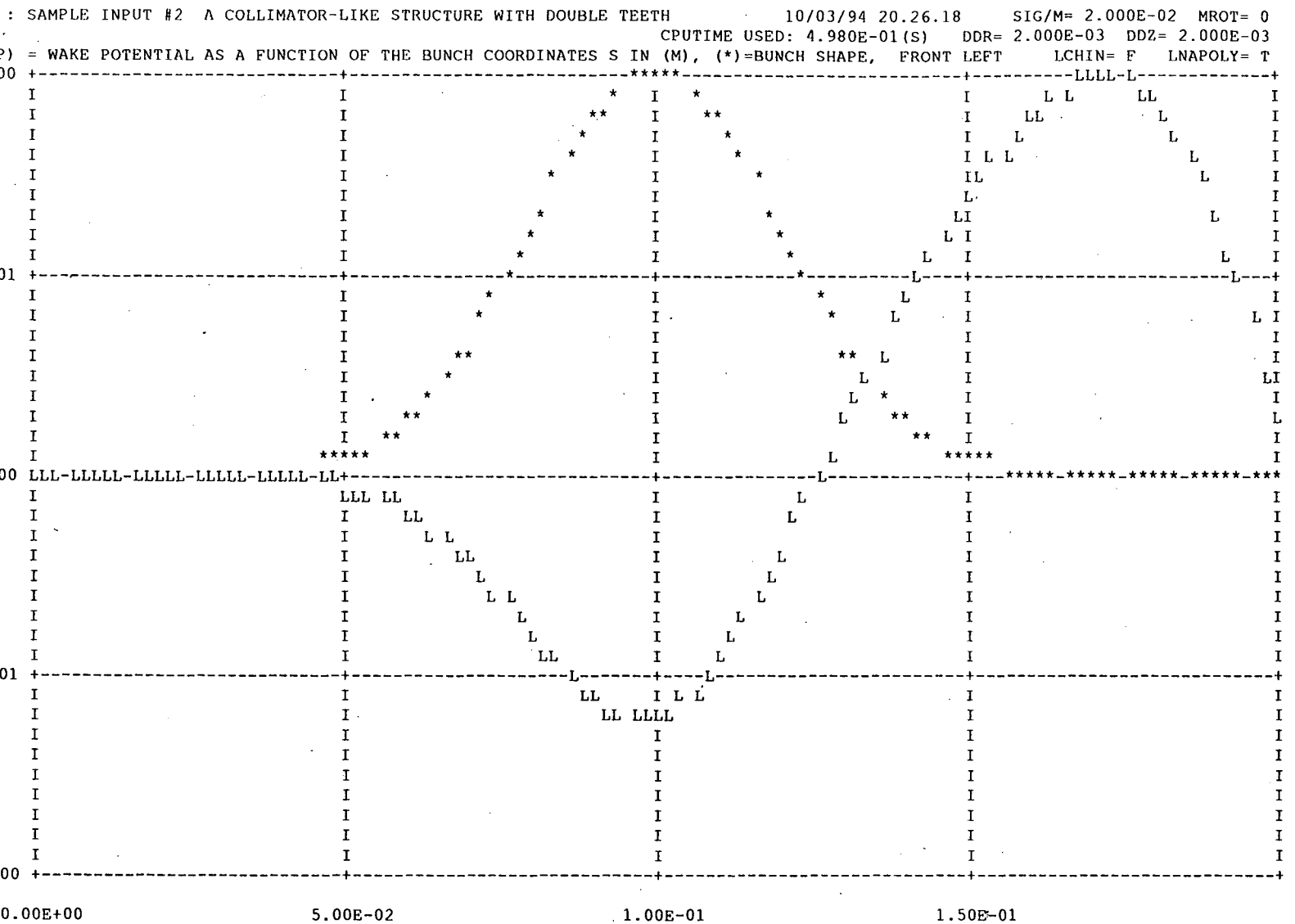
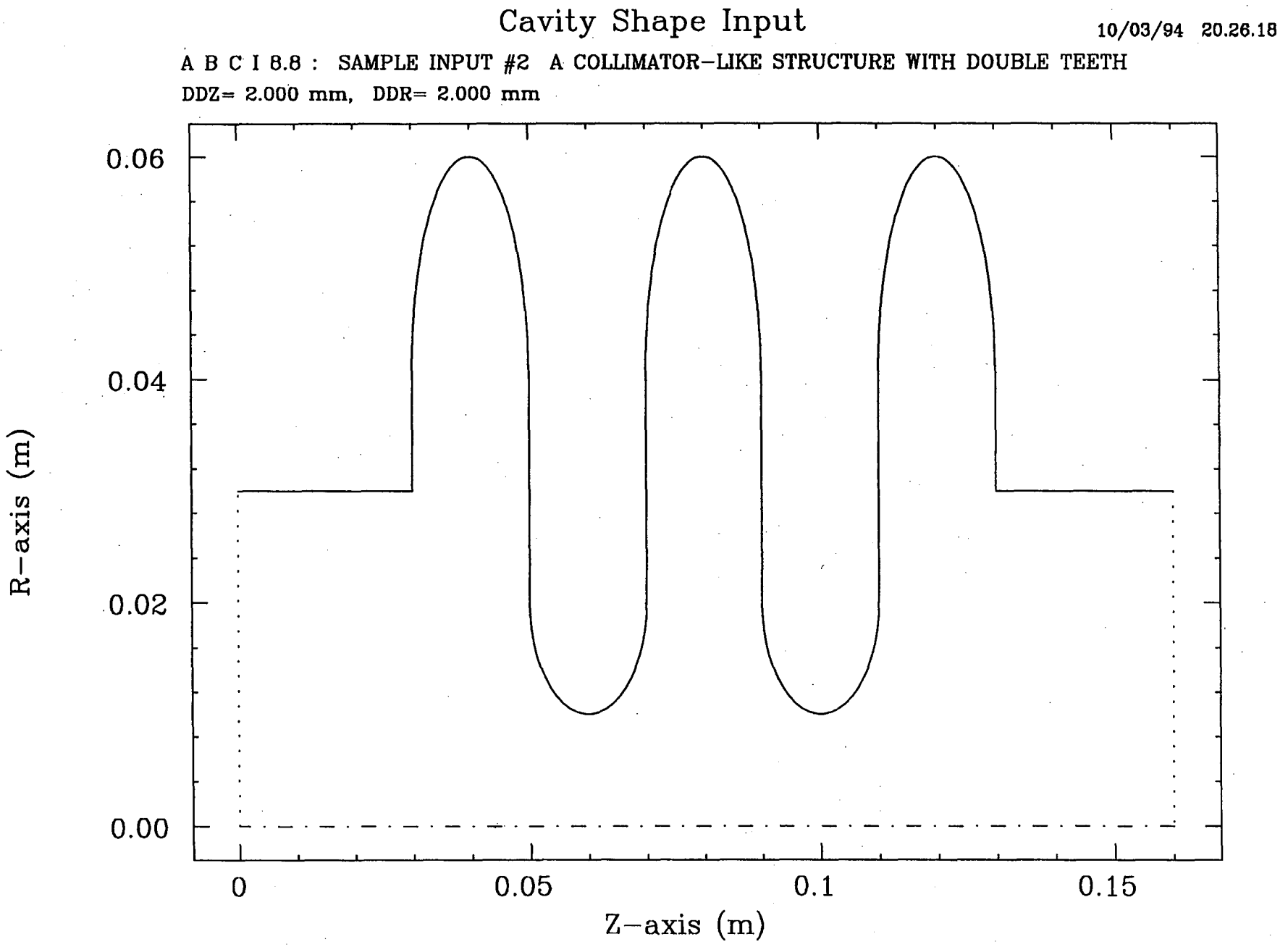
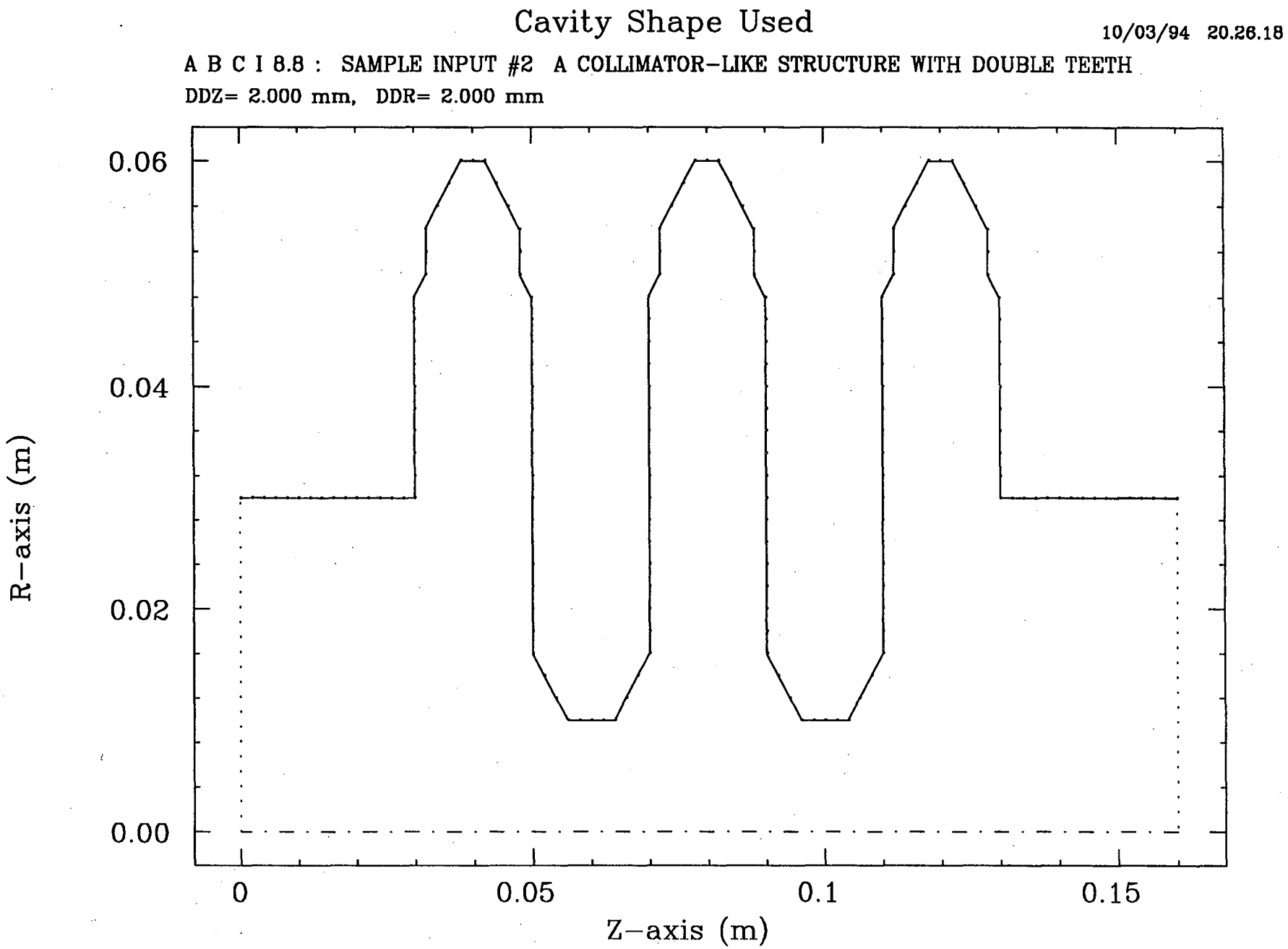
PROBLEM : SAMPLE INPUT #2 A COLLIMATOR-LIKE STRUCTURE WITH DOUBLE TEETH 10/03/94 20.26.18 SIG/M= 2.000E-02 MROT= 0
CPUTIME USED: 4.980E-01(S) DDR= 2.000E-03 DDZ= 2.000E-03
(A,T,L,P) = WAKE POTENTIAL AS A FUNCTION OF THE BUNCH COORDINATES S IN (M), (*)=BUNCH SHAPE, FRONT LEFT LCHIN= F LNAPOLY= T

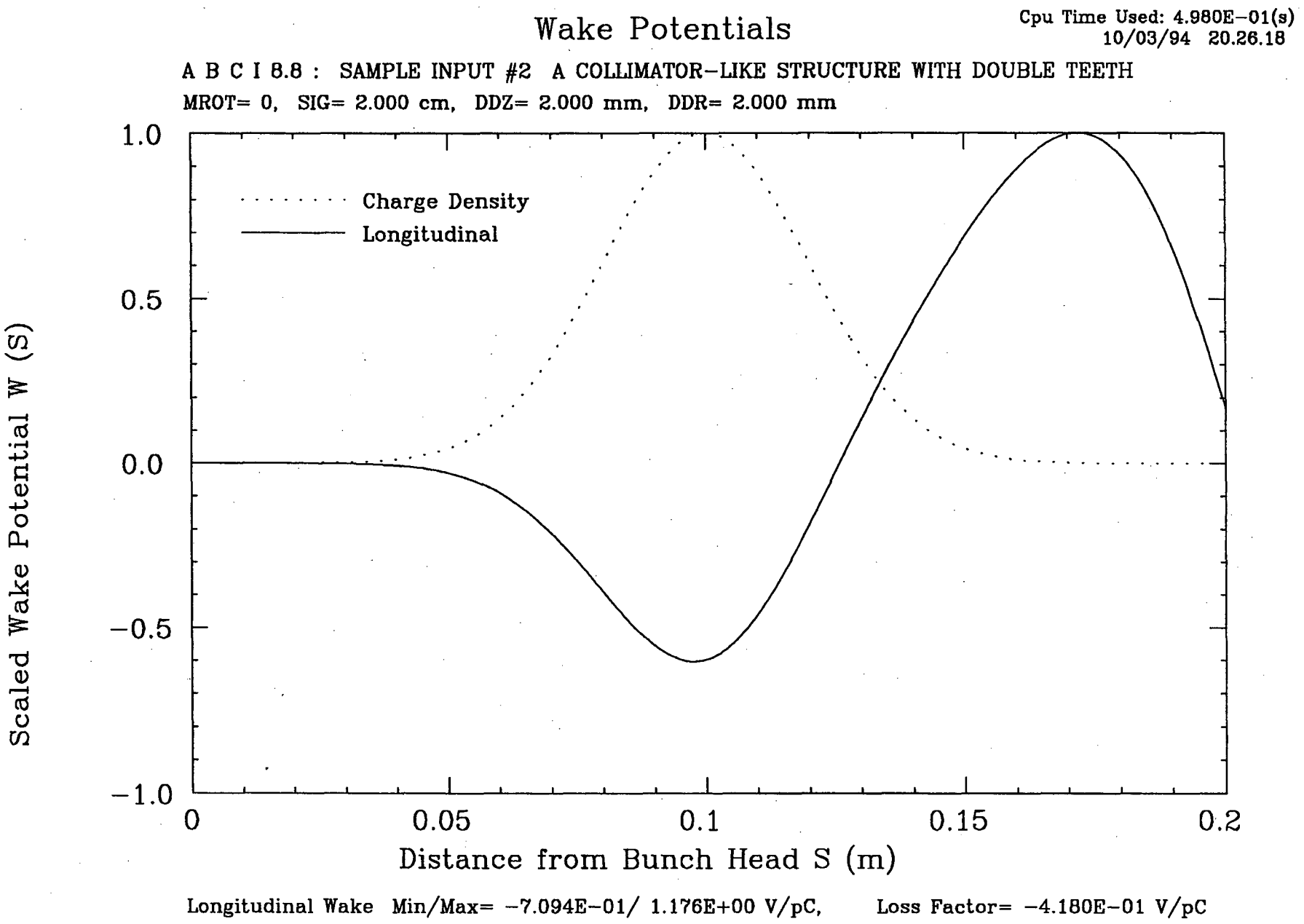


LINE CHARGE DENSITY MIN/MAX= 0.000E+00/ 1.995E+01 C/M**1, SCALE= 1.995E+01 C/M**1, PASSING AT R= 1.000E-02 M
LONGITUDINAL WAKE MIN/MAX=-7.094E-01/ 1.176E+00 V/PC/M**0, SCALE= 1.176E+00 V/PC/M**0

INTEGRATED LONGITUDINAL WAKE * CHARGE DENSITY = -4.180E-01 V/PC/M**0


Cavity Shape Input
10/03/94 20.26.18
A B C I 8.8 : SAMPLE INPUT #2 A COLLIMATOR-LIKE STRUCTURE WITH DOUBLE TEETH
DDZ= 2.000 mm, DDR= 2.000 mm
0.06
0.04
0.02
0.00
R-axis (m)
0
0.05
0.1
0.15
Z-axis (m)


Cavity Shape Used
10/03/94 20.26.18
A B C I 8.8 : SAMPLE INPUT #2 A COLLIMATOR-LIKE STRUCTURE WITH DOUBLE TEETH
DDZ= 2.000 mm, DDR= 2.000 mm
0.06
0.04
0.02
0.00
R-axis (m)
0
0.05
0.1
0.15
Z-axis (m)

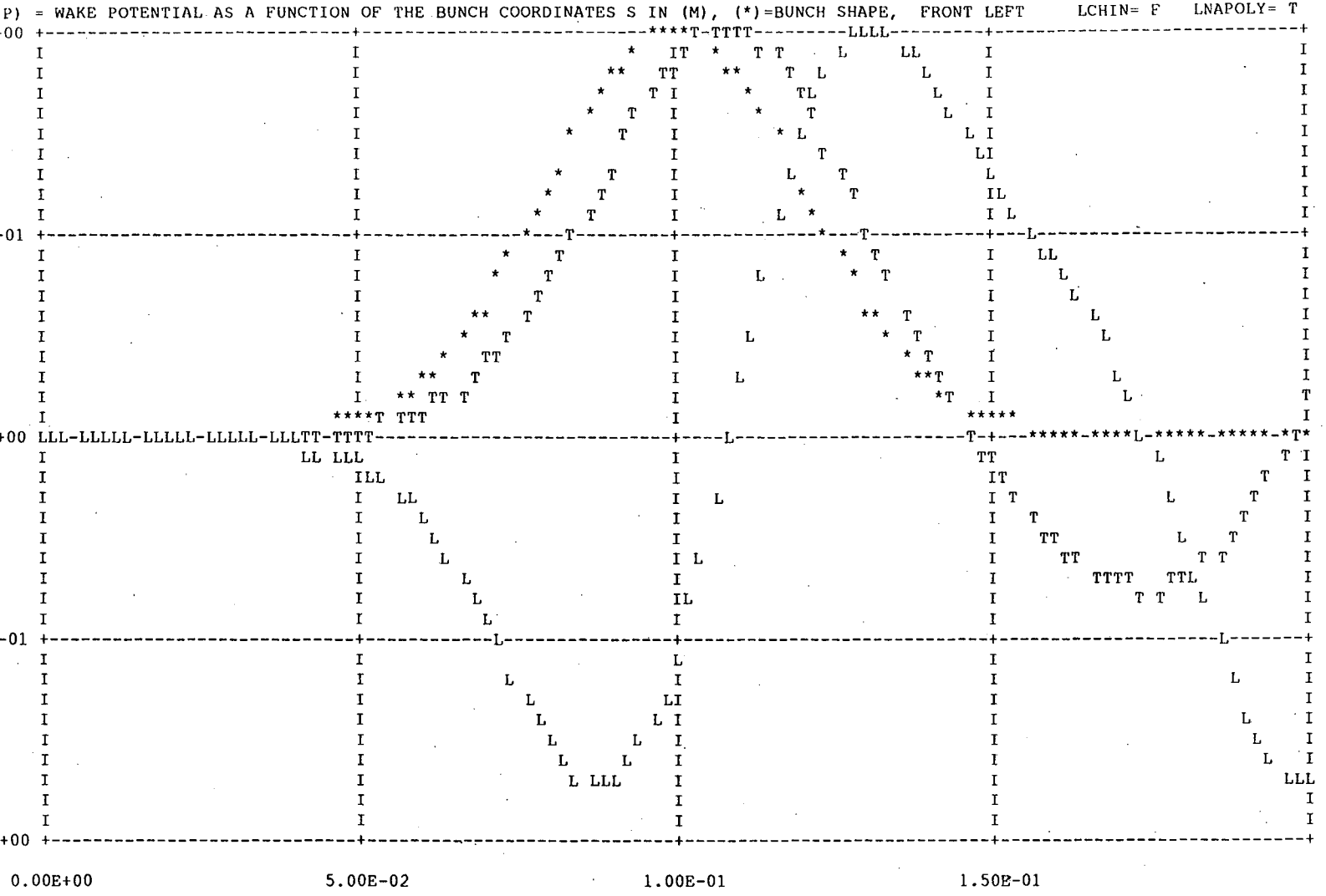

Wake Potentials
Cpu Time Used: 4.980E-01(s)
10/03/94 20.26.18
A B C I 8.8 : SAMPLE INPUT #2 A COLLIMATOR-LIKE STRUCTURE WITH DOUBLE TEETH
MROT= 0, SIG= 2.000 cm, DDZ= 2.000 mm, DDR= 2.000 mm
Charge Density
Longitudinal
1.0
0.5
0.0
-0.5
-1.0
0
0.05
0.1
0.15
0.2
Scaled Wake Potential W (S)
Distance from Bunch Head S (m)
Longitudinal Wake Min/Max= -7.094E-01/ 1.176E+00 V/pC, Loss Factor= -4.180E-01 V/pC

```
*************************************************************************
*                                                                       *
*                            ABCI   2ND RUN                             *
*                                                                       *
*   DATE:10/03/94   TIME:20.26.19     VERSION 8.8,  FEBRUARY  1994      *
*                                                                       *
*************************************************************************

*** WARNING *** YOU DID NOT FULLY SPECIFY THE INTEGRATION CONTURE DESPITE OF LNAPOLY=T.
*** ABCI CHOOSES THE FOLLOWING CONTURE: ***
ZCF=  0.46000E-01(M)    ZCT=  0.11400    (M)    AND RWAK=  0.10000E-01(M)
YOU SHOULD STILL CHECK IF THIS CONTURE IS VALID OR NOT.

*** CAUTION *** YOU MUST NOW USE NAPOLY INTEGRATION FOR CALCULATION OF THE WAKE POTENTIALS.
YOUR CASE: LNAPOLY= T
IF LNAPOLY=F, ABCI NOW CHANGES IT TO LNAPOLY=T.
CHECK IF THE CONTURE IS VALID.
```

PROBLEM : SAMPLE INPUT #2 A COLLIMATOR-LIKE STRUCTURE WITH DOUBLE TEETH 10/03/94 20.26.18 SIG/M= 2.000E-02 MROT= 1
CPUTIME USED: 7.782E-01(S) DDR= 2.000E-03 DDZ= 2.000E-03
(A,T,L,P) = WAKE POTENTIAL AS A FUNCTION OF THE BUNCH COORDINATES S IN (M), (*)=BUNCH SHAPE, FRONT LEFT LCHIN= F LNAPOLY= T



LINE CHARGE DENSITY MIN/MAX= 0.000E+00/ 1.995E+01 C/M**1, SCALE= 1.995E+01 C/M**1, PASSING AT R= 1.000E-02 M
TRANSVERSE WAKE MIN/MAX=-3.747E+01/ 9.950E+01 V/PC/M**1, SCALE= 9.950E+01 V/PC/M**1, NORMALIZED BY D= 1.000E-02 M DIPOLE OFFSET
LONGITUDINAL WAKE MIN/MAX=-8.814E+01/ 1.028E+02 V/PC/M**2, SCALE= 3.426E+03 V/PC/M**2, NORMALIZED BY D= 1.000E-02 M DIPOLE OFFSET

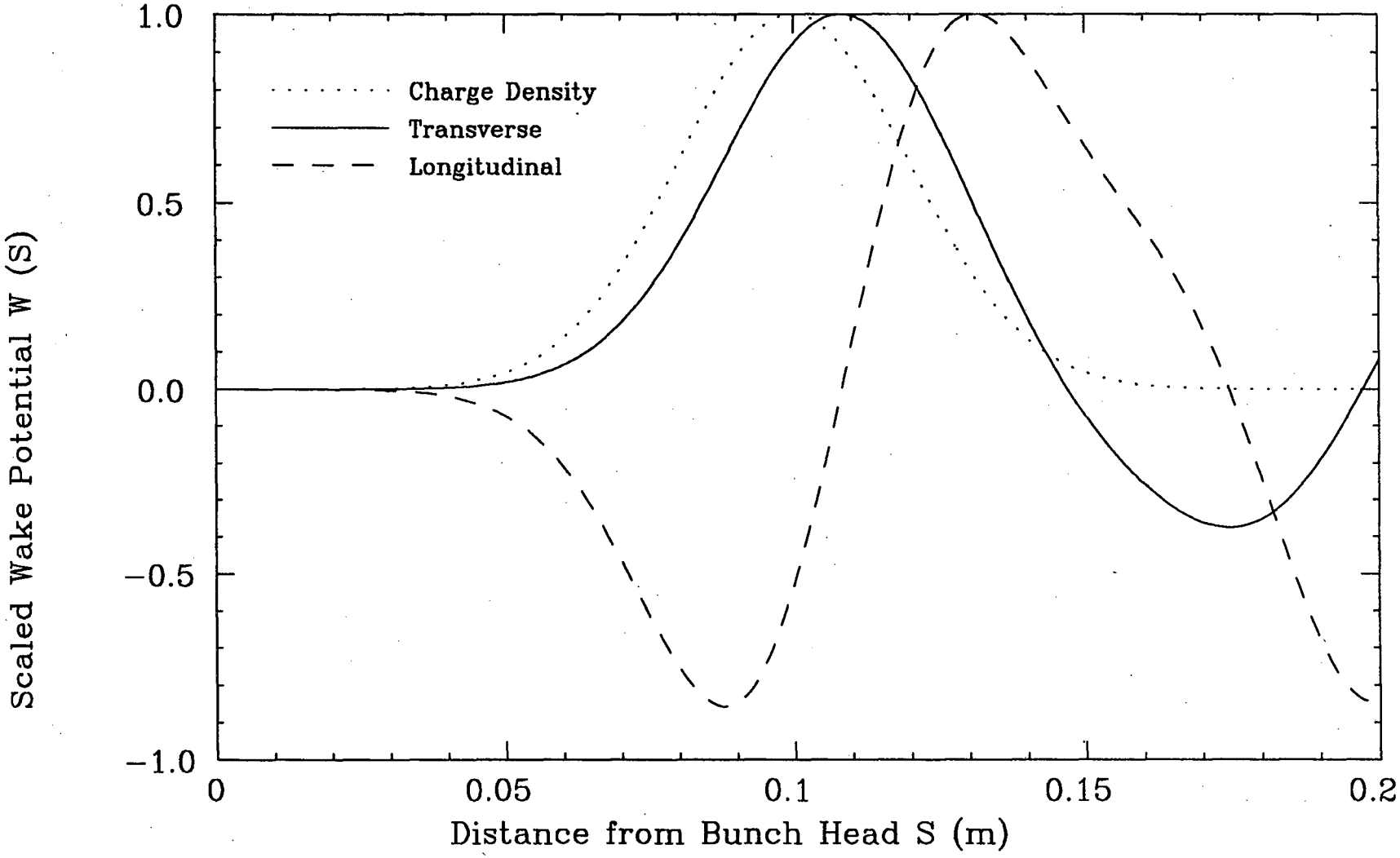
INTEGRATED TRANSVERSE WAKE * CHARGE DENSITY = 6.736E+01 V/PC/M**1
INTEGRATED LONGITUDINAL WAKE * CHARGE DENSITY = -5.942E+02 V/PC/M**2

Wake Potentials

Cpu Time Used: 7.782E-01(s)
10/03/94 20.26.18

A B C I 6.8 : SAMPLE INPUT #2 A COLLIMATOR-LIKE STRUCTURE WITH DOUBLE TEETH

MROT= 1, SIG= 2.000 cm, DDZ= 2.000 mm, DDR= 2.000 mm



Transverse Wake Min/Max= −3.747E+01/ 9.950E+01 V/pC/m, Loss Factor= 6.736E+01 V/pC/m
Longitudinal Wake Min/Max= −2.938E+03/ 3.426E+03 V/pC/m^2, Loss Factor= −5.942E+02 V/pC/m^2

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*************************************************************************
*                                                                       *
*                          ABCI   3RD RUN                               *
*                                                                       *
*   DATE:10/03/94   TIME:20.26.20     VERSION 8.8,  FEBRUARY  1994       *
*                                                                       *
*************************************************************************


$FILE:
SAVE FIELDS INTO FILE  (LSAV)   :  F
RECOVER FROM FILE      (LREC)   :  F
CPUTIME MONITOR ACTIVE (LCPUTM):  F

$BOUN:
BOUNDARY CONDITIONS     LEFT   : OPEN
BOUNDARY CONDITIONS     RIGHT  : OPEN

$MESH:
NUMBER OF MESH LINES IN R       : NR   =      31
NUMBER OF MESH LINES IN Z       : NZ   =      80
NUMBER OF MESH POINTS           : NP   =    2480
TOTAL RADIUS OF THE STRUCTURE   : RAD  =  0.60000E-01(M)
TOTAL LENGTH OF THE STRUCTURE   : ZL   =  0.16000    (M)
STEP SIZE IN R                  : DDR  =  0.20000E-02(M)
STEP SIZE IN Z                  : DDZ  =  0.20000E-02(M)
STRUCTURE INPUT VARIABLE        : RZ  1=  0.25000E-01(M)
STRUCTURE INPUT VARIABLE        : RZ  2=  0.15000E-01(M)

@CAVITYSHAPE (@@CAVITYSHAPE) :  FULL CELL INPUT

INPUT:       (R, Z)                    (IR, IZ)
(   0.00000E+00  0.00000E+00 )  (       1       1 ) ---> (   0.00000E+00  0.00000E+00 )
(   0.30000E-01  0.00000E+00 )  (      16       1 ) ---> (   0.30000E-01  0.00000E+00 )
(   0.00000E+00  0.30000E-01 )  (      16      16 ) ---> (   0.30000E-01  0.30000E-01 )
(   0.10000E-01  0.00000E+00 )  (      21      16 ) ---> (   0.40000E-01  0.30000E-01 )
CONNECTED BY AN ELLIPSE,       IKIND=-3,  (RM, ZM)=      (   0.40000E-01  0.40000E-01 )
(   0.20000E-01  0.00000E+00 )  (      31      21 ) ---> (   0.60000E-01  0.40000E-01 )
CONNECTED BY AN ELLIPSE,       IKIND=-3,  (RM, ZM)=      (   0.40000E-01  0.40000E-01 )
(   0.00000E+00  0.10000E-01 )  (      21      26 ) ---> (   0.40000E-01  0.50000E-01 )
(  -0.20000E-01  0.00000E+00 )  (      11      26 ) ---> (   0.20000E-01  0.50000E-01 )
CONNECTED BY A CONCAVE CIRCLE, IKIND=-1,  RADIUS=  0.10000E-01
(   0.00000E+00  0.20000E-01 )  (      11      36 ) ---> (   0.20000E-01  0.70000E-01 )
(   0.20000E-01  0.00000E+00 )  (      21      36 ) ---> (   0.40000E-01  0.70000E-01 )
CONNECTED BY AN ELLIPSE,       IKIND=-3,  (RM, ZM)=      (   0.40000E-01  0.80000E-01 )
(   0.20000E-01  0.00000E+00 )  (      31      41 ) ---> (   0.60000E-01  0.80000E-01 )
CONNECTED BY AN ELLIPSE,       IKIND=-3,  (RM, ZM)=      (   0.40000E-01  0.80000E-01 )
(   0.00000E+00  0.10000E-01 )  (      21      46 ) ---> (   0.40000E-01  0.90000E-01 )
(  -0.20000E-01  0.00000E+00 )  (      11      46 ) ---> (   0.20000E-01  0.90000E-01 )
CONNECTED BY A CONCAVE CIRCLE, IKIND=-1,  RADIUS=  0.10000E-01
(   0.00000E+00  0.20000E-01 )  (      11      56 ) ---> (   0.20000E-01  0.11000     )
(   0.20000E-01  0.00000E+00 )  (      21      56 ) ---> (   0.40000E-01  0.11000     )
CONNECTED BY AN ELLIPSE,       IKIND=-3,  (RM, ZM)=      (   0.40000E-01  0.12000     )
(   0.20000E-01  0.00000E+00 )  (      31      61 ) ---> (   0.60000E-01  0.12000     )
CONNECTED BY AN ELLIPSE,       IKIND=-3,  (RM, ZM)=      (   0.40000E-01  0.12000     )
(   0.00000E+00  0.10000E-01 )  (      21      66 ) ---> (   0.40000E-01  0.13000     )
(      -RZ  1    0.00000E+00 )  (       8      66 ) ---> (   0.15000E-01  0.13000     ) ---> (   0.14000E-01  0.13000     )
(   0.00000E+00  0.30000E-01 )  (       8      80 ) ---> (   0.15000E-01  0.16000     ) ---> (   0.14000E-01  0.16000     )
(      -RZ  2    0.00000E+00 )  (       1      81 ) ---> (   0.00000E+00  0.16000     )
(   0.00000E+00 -0.16000     )  (       1       1 ) ---> (   0.00000E+00  0.00000E+00 )
```

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$BEAM:
SIGMA OF THE GAUSSIAN BUNCH     : SIG  =  0.20000E-01(M)
NUMBER OF STAND.DEV. USED       : ISIG = +/-  5
RADIAL BEAM OFFSET AT           :RDRIVE=  0.10000E-01(M)
MODE NUMBER (MONOPOLE/DIPOLE)   : MROT =      0

$WAKE:
RADIAL WAKE OFFSET        (LEFT)   AT  R   =  0.30000E-01(M)
                          (RIGHT)  AND R   =  0.14000E-01(M)
WAKE    BETWEEN THE BUNCH  COORDINATES UBF =  0.00000E+00(M)
                                  AND UBT =  0.20000    (M)
WINDOW FOR FRONT                 (LCFRON)  :  T
WINDOW FOR BACK                  (LCBACK)  :  T
CHIN WAKE INTEGRATION METHOD     (LCHIN )  :  F
NAPOLY WAKE INTEGRATION METHOD   (LNAPOLY) :  T
STARTING Z FOR INTEGRAL AT RWAK: ZCF  =  0.20000E-01(M)
LAST Z FOR INTEGRAL AT RWAK     : ZCT  =  0.15000    (M)
RADIAL OFFSET FOR WAKE INTEGRAL: RWAK =  0.10000E-01(M)
NUMBER OF WAKE POTENTIAL POINTS: NW   =     101

$TIME:
TIME STEPS TO BE PROCESSED      : NT   =    544
NUMBER OF TIME STEPS/MESH STEP  : MT   =      3
VELOCITY OF THE BUNCH / C       : BETA =   1.0000
TIME-STEP VALUE                 : DT   =   2.2238    (PS)
TIME FOR A PARTICLE TO PASS     : PT   =   533.70    (PS)

$PLOT:
PLOT OF CAVITY SHAPE INPUT       (LCAVIN)  :  T
PLOT OF CAVITY SHAPE USED        (LCAVUS)  :  F
PLOT OF ALL WAKE POTENTIALS      (LPLW)    :  T
PLOT OF AZIMUTHAL WAKE POTENTIAL (LPLWA)   :  F
PLOT OF TRANSVERSE WAKE POTENT.  (LPLWT)   :  F
PLOT OF LONGITUDINAL WAKE POTENT.(LPLWL)   :  F
PLOT OF FFT OF WAKE POTENTIALS   (LFFT)    :  F
PLOT OF FFT OF AZIMUTHAL WAKE    (LFFTA)   :  F
PLOT OF FFT OF TRANSVERSE WAKE   (LFFTT)   :  F
PLOT OF FFT OF LONGITUDINAL WAKE (LFFTL)   :  F
PLOT OF INTEGRATION OF IMPEDANCE (LINTZ)   :  F
PLOT OF ENERGY LOSS SPECTRUM     (LSPEC)   :  F
PLOT OF ELECTRIC FIELD LINES     (LPLE)    :  F
PLOT OF TOTAL CURRENT LINES      (LPLC)    :  F
SWITCH FROM ABSOLUTE TO RELATVE  (LPALL)   :  F
NUMBER OF CONTURE LINES         : NPLOT=      10
CUTOFF FREQUENCY FOR FFT PLOT   :CUTOFF=   5.8436    (GHZ)
WINDOWING FOR FOURIER TRANSFORMS (LWNDW)   :  T
WINDOW FUNCTION                 : NWFUN=       1
WINDOW PARAMETER FOR WIDTH      : ALPHA=  3.0000

$PRIN:
PRINTOUT OF CAVITY SHAPE USED    (LMATPR)  :  T
PRINTOUT OF WAKE POTENTIALS      (LPRW)    :  F
SAVE WAKE POTENTIALS IN A FILE   (LSVW)    :  F
SAVE AZIMUTHAL WAKE IN A FILE    (LSVWA)   :  F
SAVE TRANSVERSE WAKE IN A FILE   (LSVWT)   :  F
SAVE LONGITUDINAL WAKE IN A FILE (LSVWL)   :  F
SAVE FFT RESULTS IN A FILE       (LSVF)    :  F

*** CAUTION *** YOU MUST NOW USE NAPOLY INTEGRATION FOR CALCULATION OF THE WAKE POTENTIALS.
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```
YOUR CASE: LNAPOLY= T
IF LNAPOLY=F, ABCI NOW CHANGES IT TO LNAPOLY=T.
CHECK IF THE CONTURE IS VALID.
```

CAVITY SHAPE

.=VACUUM ; \,/=TRIANGULAR FILLED MESH CELL ; *=FULL METAL ; B=BEAM

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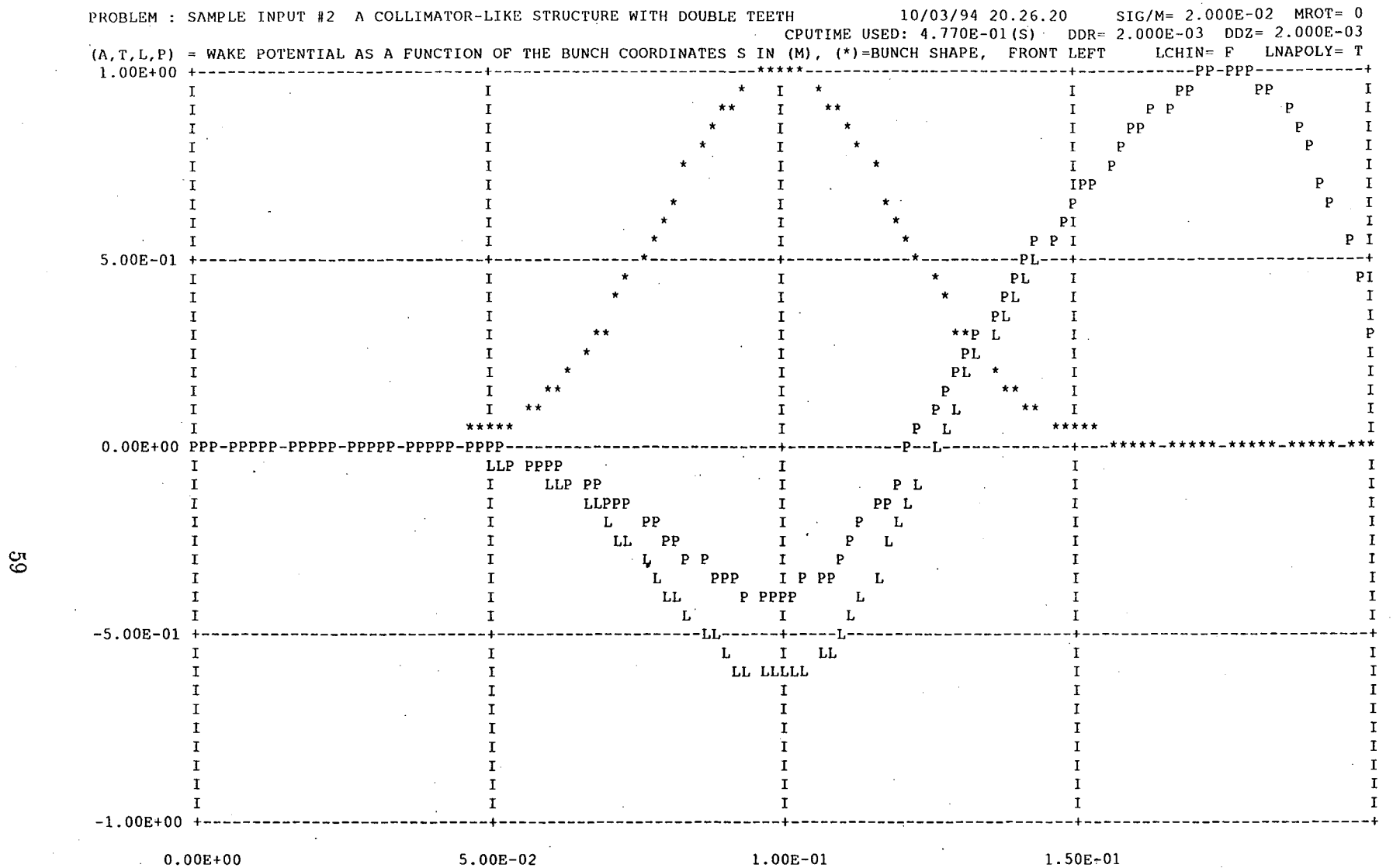
PROBLEM : SAMPLE INPUT #2 A COLLIMATOR-LIKE STRUCTURE WITH DOUBLE TEETH 10/03/94 20.26.20 SIG/M= 2.000E-02 MROT= 0
CPUTIME USED: 4.770E-01(S) DDR= 2.000E-03 DDZ= 2.000E-03
(A,T,L,P) = WAKE POTENTIAL AS A FUNCTION OF THE BUNCH COORDINATES S IN (M), (*)=BUNCH SHAPE, FRONT LEFT LCHIN= F LNAPOLY= T



LINE CHARGE DENSITY MIN/MAX= 0.000E+00/ 1.995E+01 C/M**1, SCALE= 1.995E+01 C/M**1, PASSING AT R= 1.000E-02 M
LONGITUDINAL WAKE MIN/MAX=-7.603E-01/ 1.235E+00 V/PC/M**0, SCALE= 1.235E+00 V/PC/M**0
WAKE WITH LOG, TERM MIN/MAX=-4.884E-01/ 1.235E+00 V/PC/M**0, SCALE= 1.235E+00 V/PC/M**0

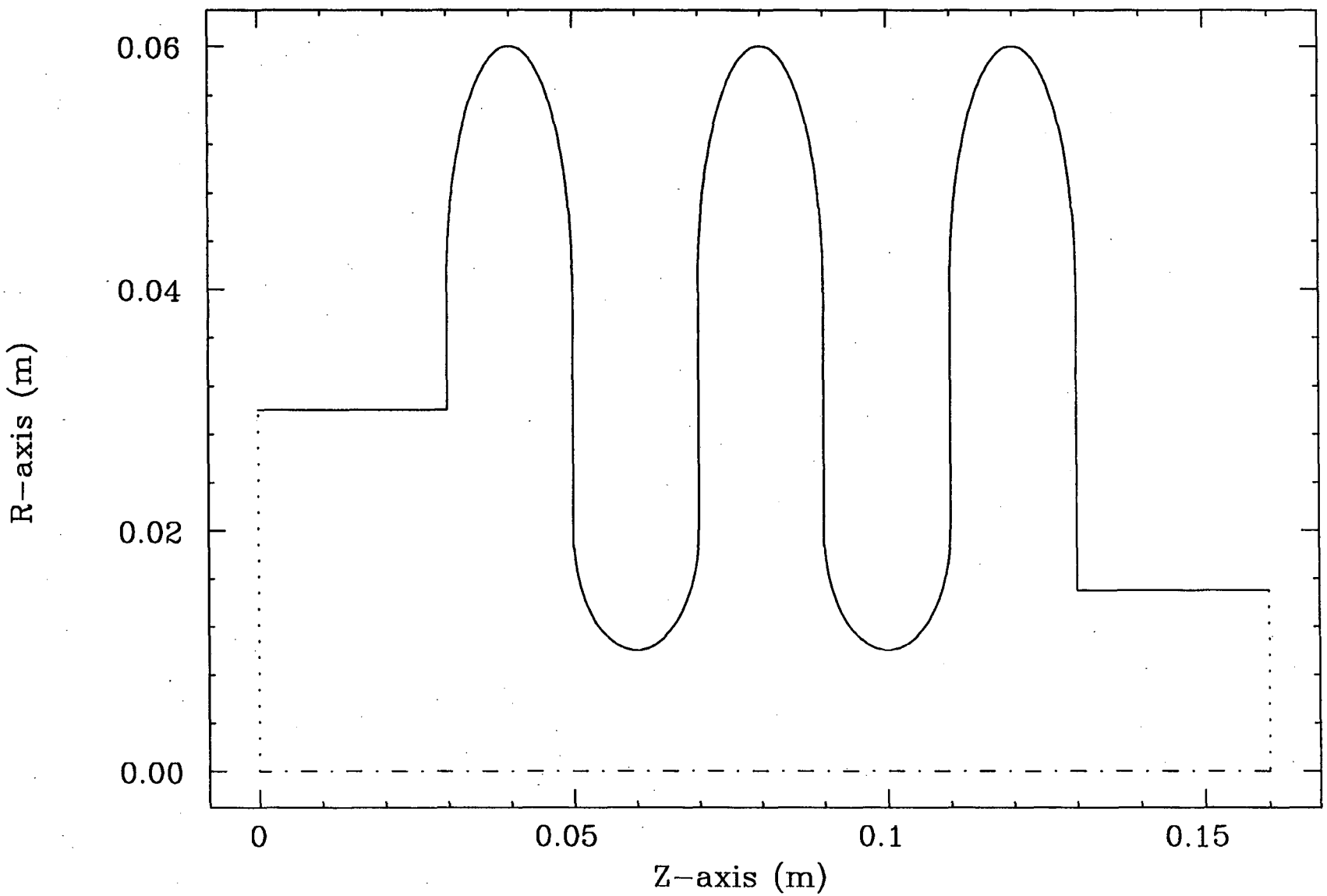
INTEGRATED LONGITUDINAL WAKE * CHARGE DENSITY = -4.512E-01 V/PC/M**0
WITH LOG. TERM DUE TO UNEQUAL BEAM PIPE RADII = -2.580E-01 V/PC/M**0

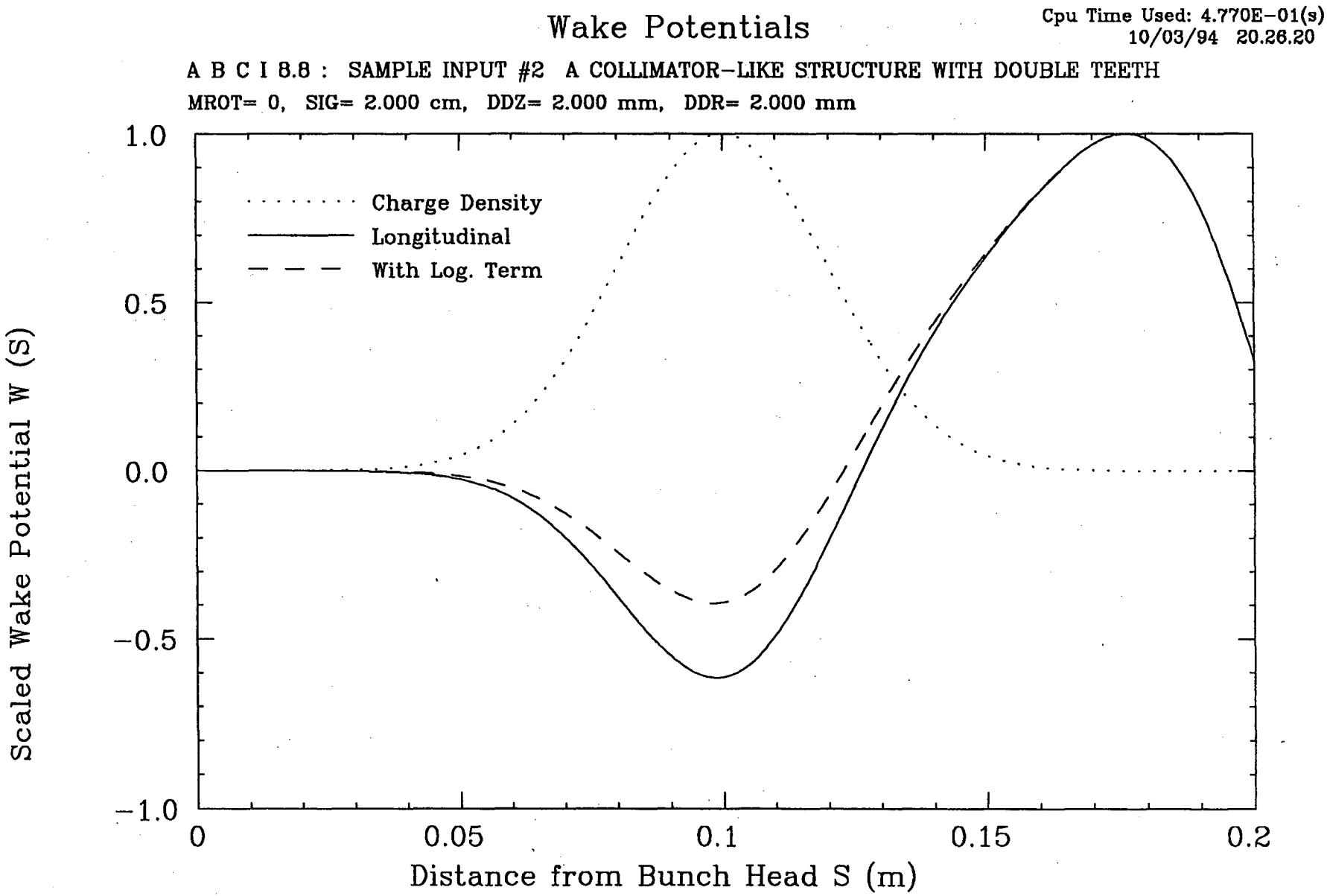
Cavity Shape Input

10/03/94 20.26.20

A B C I 8.8 : SAMPLE INPUT #2 A COLLIMATOR-LIKE STRUCTURE WITH DOUBLE TEETH

DDZ= 2.000 mm, DDR= 2.000 mm





Longitudinal Wake Min/Max= −7.603E−01/ 1.235E+00 V/pC, Loss Factor= −4.512E−01 V/pC
With Log. Term Min/Max= −4.884E−01/ 1.235E+00 V/pC, Loss Factor= −2.580E−01 V/pC

```
*****************************************************************************
*                                                                           *
*                                  ABCI                                     *
*                                                                           *
* Azimuthal Beam Cavity Interaction in a cylindrically symmetric structure *
*                                                                           *
*  SAMPLE INPUT #3  A MONITOR-LIKE STRUCTURE WITH A CUTTING EDGE            *
*                                                                           *
*     DATE:10/03/94   TIME:20.28.42     VERSION 8.8,  FEBRUARY  1994        *
*                                                                           *
*****************************************************************************


$FILE:
SAVE FIELDS INTO FILE   (LSAV)   :  F
RECOVER FROM FILE       (LREC)   :  F
CPUTIME MONITOR ACTIVE  (LCPUTM):  F

$BOUN:
BOUNDARY CONDITIONS      LEFT   : OPEN
BOUNDARY CONDITIONS      RIGHT  : OPEN

$MESH:
NUMBER OF MESH LINES IN R       : NR   =      41
NUMBER OF MESH LINES IN Z       : NZ   =      44
NUMBER OF MESH POINTS           : NP   =    1804
TOTAL RADIUS OF THE STRUCTURE   : RAD  =  0.20000E-01(M)
TOTAL LENGTH OF THE STRUCTURE   : ZL   =  0.22000E-01(M)
STEP SIZE IN R                  : DDR  =  0.50000E-03(M)
STEP SIZE IN Z                  : DDZ  =  0.50000E-03(M)

#CAVITYSHAPE (##CAVITYSHAPE) :  FULL CELL INPUT

INPUT:        (R, Z)                    (IR, IZ)
(   0.00000E+00  0.00000E+00 )  (       1       1 )
(   0.20000E-01  0.00000E+00 )  (      41       1 )
(   0.20000E-01  0.10000E-01 )  (      41      21 )
(   0.19000E-01  0.10000E-01 )  (      39      21 )
(   0.19000E-01  0.12000E-01 )  (      39      25 )
(   0.20000E-01  0.12000E-01 )  (      41      25 )
(   0.20000E-01  0.22000E-01 )  (      41      44 )
(   0.00000E+00  0.22000E-01 )  (       1      45 )
(   0.00000E+00  0.00000E+00 )  (       1       1 )
(   0.16000E-01  0.50000E-02 )  (      33      11 )
(   0.16000E-01  0.17000E-01 )  (      33      35 )
(   0.16500E-01  0.17000E-01 )  (      34      35 )
(   0.16500E-01  0.12000E-01 )  (      34      25 )
(   0.17500E-01  0.12000E-01 )  (      36      25 )
(   0.17500E-01  0.10000E-01 )  (      36      21 )
(   0.16500E-01  0.10000E-01 )  (      34      21 )
(   0.16500E-01  0.50000E-02 )  (      34      11 )
(   0.16000E-01  0.50000E-02 )  (      33      11 )

$BEAM:
SIGMA OF THE GAUSSIAN BUNCH     : SIG  =  0.20000E-02(M)
NUMBER OF STAND.DEV. USED       : ISIG = +/-  5
RADIAL BEAM OFFSET AT           :RDRIVE=  0.00000E+00(M)
MODE NUMBER (MONOPOLE/DIPOLE)   : MROT =      0
NUMBER OF GAUSSIAN BUNCHES      :NBUNCH=      2
```

Figure 8: Output for the sample input # 3.

```
SEPARATION BETWEEN BUNCHES      : BSEP =  0.20000E-01(M)

$WAKE:
RADIAL WAKE OFFSET         (LEFT)   AT  R    =  0.20000E-01(M)
WAKE    BETWEEN THE BUNCH  COORDINATES UBF =  0.00000E+00(M)
                                     AND UBT =  0.40000E-01(M)
WINDOW FOR FRONT                  (LCFRON)  :  T
WINDOW FOR BACK                   (LCBACK)  :  F
CHIN WAKE INTEGRATION METHOD      (LCHIN )  :  F
NAPOLY WAKE INTEGRATION METHOD    (LNAPOLY) :  T
NUMBER OF WAKE POTENTIAL POINTS: NW   =      81

$TIME:
TIME STEPS TO BE PROCESSED      : NT   =    376
NUMBER OF TIME STEPS/MESH STEP : MT   =      3
VELOCITY OF THE BUNCH / C       : BETA =   1.0000
TIME-STEP VALUE                 : DT   =  0.55594     (PS)
TIME FOR A PARTICLE TO PASS     : PT   =   73.384     (PS)
START TIME FOR FILED LINE PLOT : TPS  =  0.00000E+00(PS)
NUMBER OF FILED LINE PLOTS      : NSHOT=      7

$PLOT:
PLOT OF CAVITY SHAPE INPUT        (LCAVIN)  :  F
PLOT OF CAVITY SHAPE USED         (LCAVUS)  :  F
PLOT OF ALL WAKE POTENTIALS       (LPLW)    :  T
PLOT OF AZIMUTHAL WAKE POTENTIAL (LPLWA)    :  F
PLOT OF TRANSVERSE WAKE POTENT.   (LPLWT)   :  F
PLOT OF LONGITUDINAL WAKE POTENT.(LPLWL)    :  F
PLOT OF FFT OF WAKE POTENTIALS    (LFFT)    :  F
PLOT OF FFT OF AZIMUTHAL WAKE     (LFFTA)   :  F
PLOT OF FFT OF TRANSVERSE WAKE    (LFFTT)   :  F
PLOT OF FFT OF LONGITUDINAL WAKE (LFFTL)    :  F
PLOT OF INTEGRATION OF IMPEDANCE (LINTZ)    :  F
PLOT OF ENERGY LOSS SPECTRUM      (LSPEC)   :  F
PLOT OF ELECTRIC FIELD LINES      (LPLE)    :  T
PLOT OF TOTAL CURRENT LINES       (LPLC)    :  F
SWITCH FROM ABSOLUTE TO RELATVE   (LPALL)   :  F
NUMBER OF CONTURE LINES         : NPLOT=      10
CUTOFF FREQUENCY FOR FFT PLOT   :CUTOFF=   58.436     (GHZ)
WINDOWING FOR FOURIER TRANSFORMS (LWNDW)    :  T
WINDOW FUNCTION                 : NWFUN=       1
WINDOW PARAMETER FOR WIDTH      : ALPHA=   3.0000

$PRIN:
PRINTOUT OF CAVITY SHAPE USED     (LMATPR)  :  T
PRINTOUT OF WAKE POTENTIALS       (LPRW)    :  F
SAVE WAKE POTENTIALS IN A FILE    (LSVW)    :  T
SAVE AZIMUTHAL WAKE IN A FILE     (LSVWA)   :  F
SAVE TRANSVERSE WAKE IN A FILE    (LSVWT)   :  F
SAVE LONGITUDINAL WAKE IN A FILE (LSVWL)    :  F
SAVE FFT RESULTS IN A FILE        (LSVF)    :  F
*** WARNING *** YOU DID NOT FULLY SPECIFY THE INTEGRATION CONTURE DESPITE OF LNAPOLY=T.
*** ABCI CHOOSES THE FOLLOWING CONTURE: ***
ZCF=  0.40000E-02(M)     ZCT=  0.18000E-01(M)     AND RWAK=  0.16000E-01(M)
YOU SHOULD STILL CHECK IF THIS CONTURE IS VALID OR NOT.

*** CAUTION *** YOU MUST NOW USE NAPOLY INTEGRATION FOR CALCULATION OF THE WAKE POTENTIALS.
YOUR CASE: LNAPOLY= T
IF LNAPOLY=F, ABCI NOW CHANGES IT TO LNAPOLY=T.
CHECK IF THE CONTURE IS VALID.
```

CAVITY SHAPE

.=VACUUM ; \,/=TRIANGULAR FILLED MESH CELL ; *=FULL METAL ; B=BEAM

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B..........................................
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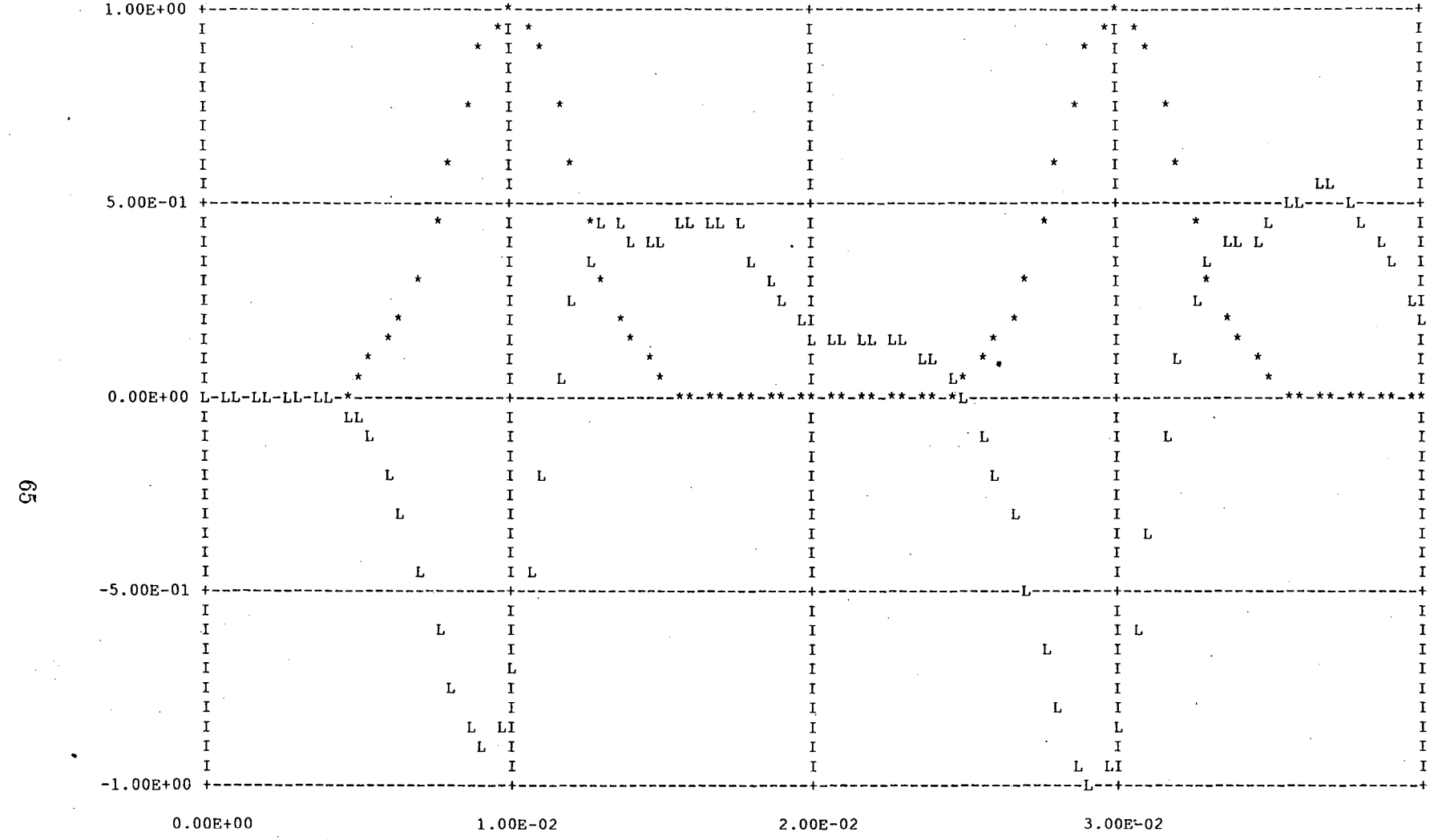
PROBLEM : SAMPLE INPUT #3 A MONITOR-LIKE STRUCTURE WITH A CUTTING EDGE 10/03/94 20.28.42 SIG/M= 2.000E-03 MROT= 0
CPUTIME USED: 7.816E-01(S) DDR= 5.000E-04 DDZ= 5.000E-04
(A,T,L,P) = WAKE POTENTIAL AS A FUNCTION OF THE BUNCH COORDINATES S IN (M), (*)=BUNCH SHAPE, FRONT LEFT LCHIN= F LNAPOLY= T



LINE CHARGE DENSITY MIN/MAX= 0.000E+00/ 9.974E+01 C/M**1, SCALE= 9.974E+01 C/M**1, PASSING AT R= 0.000E+00 M
LONGITUDINAL WAKE MIN/MAX=-2.395E-01/ 1.298E-01 V/PC/M**0, SCALE= 2.395E-01 V/PC/M**0

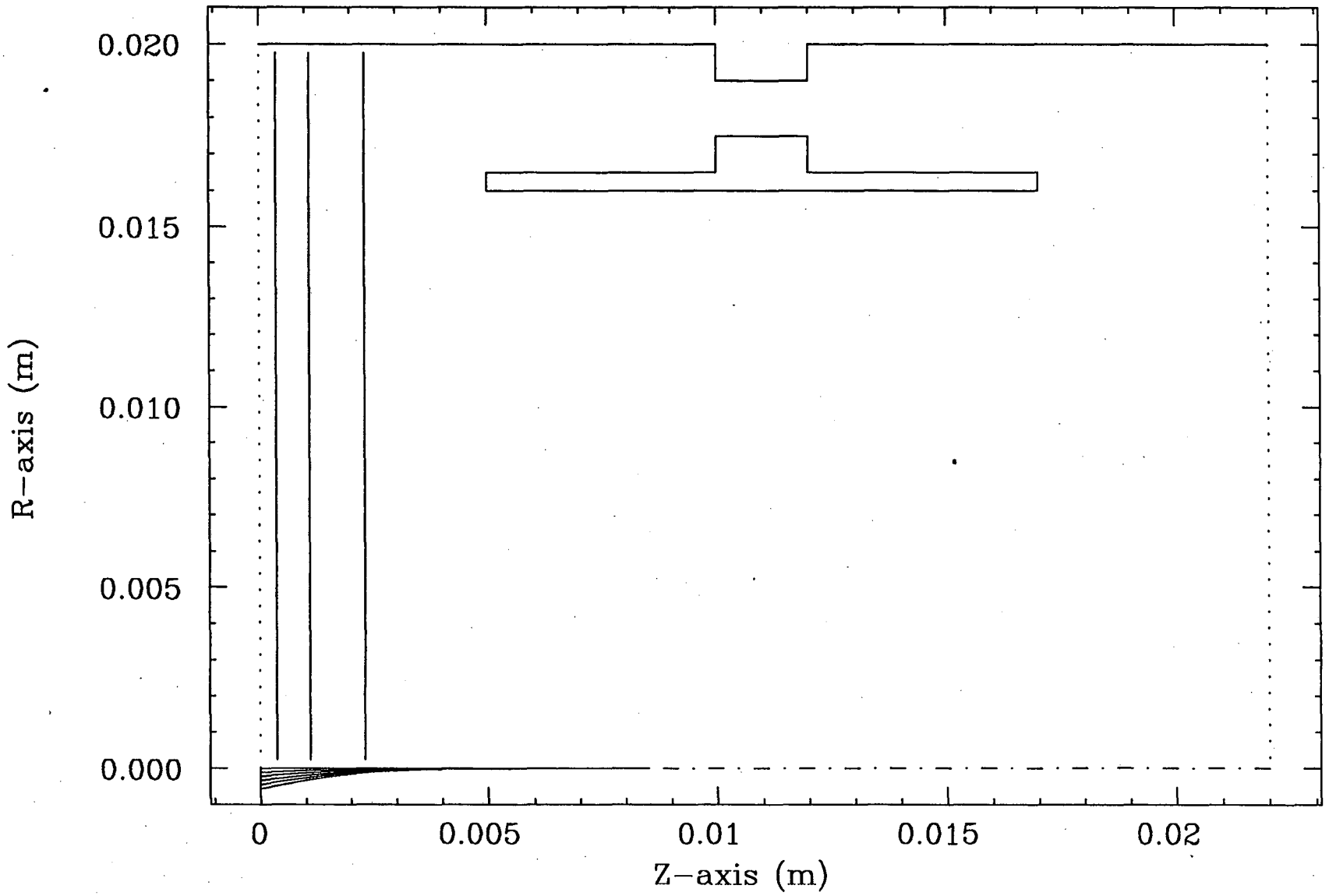
INTEGRATED LONGITUDINAL WAKE * CHARGE DENSITY = -1.045E-01 V/PC/M**0

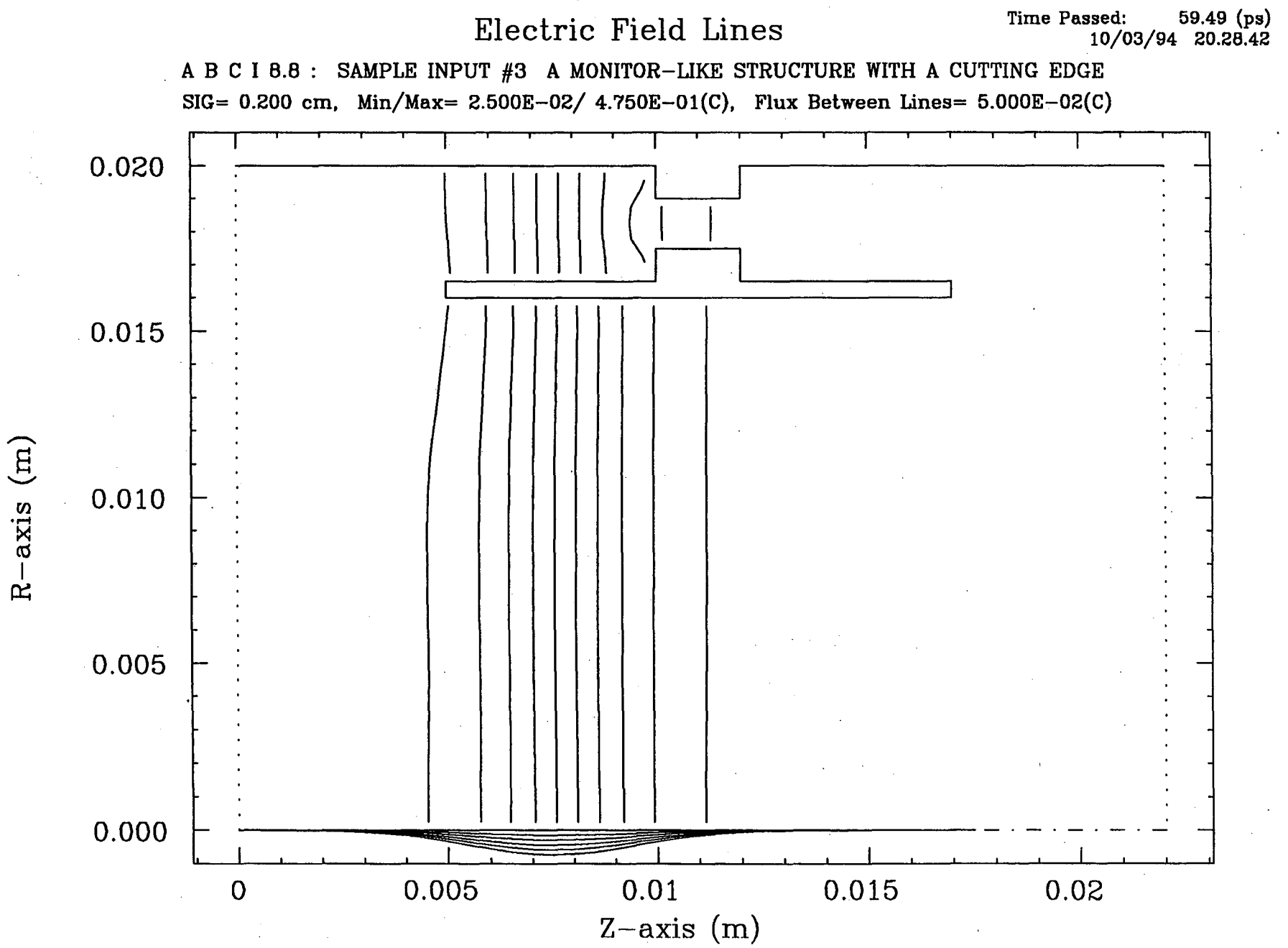
Electric Field Lines

Time Passed: 30.02 (ps)
10/03/94 20.28.42

A B C I 8.8 : SAMPLE INPUT #3 A MONITOR-LIKE STRUCTURE WITH A CUTTING EDGE

SIG= 0.200 cm, Min/Max= 2.500E-02/ 1.250E-01(C), Flux Between Lines= 5.000E-02(C)



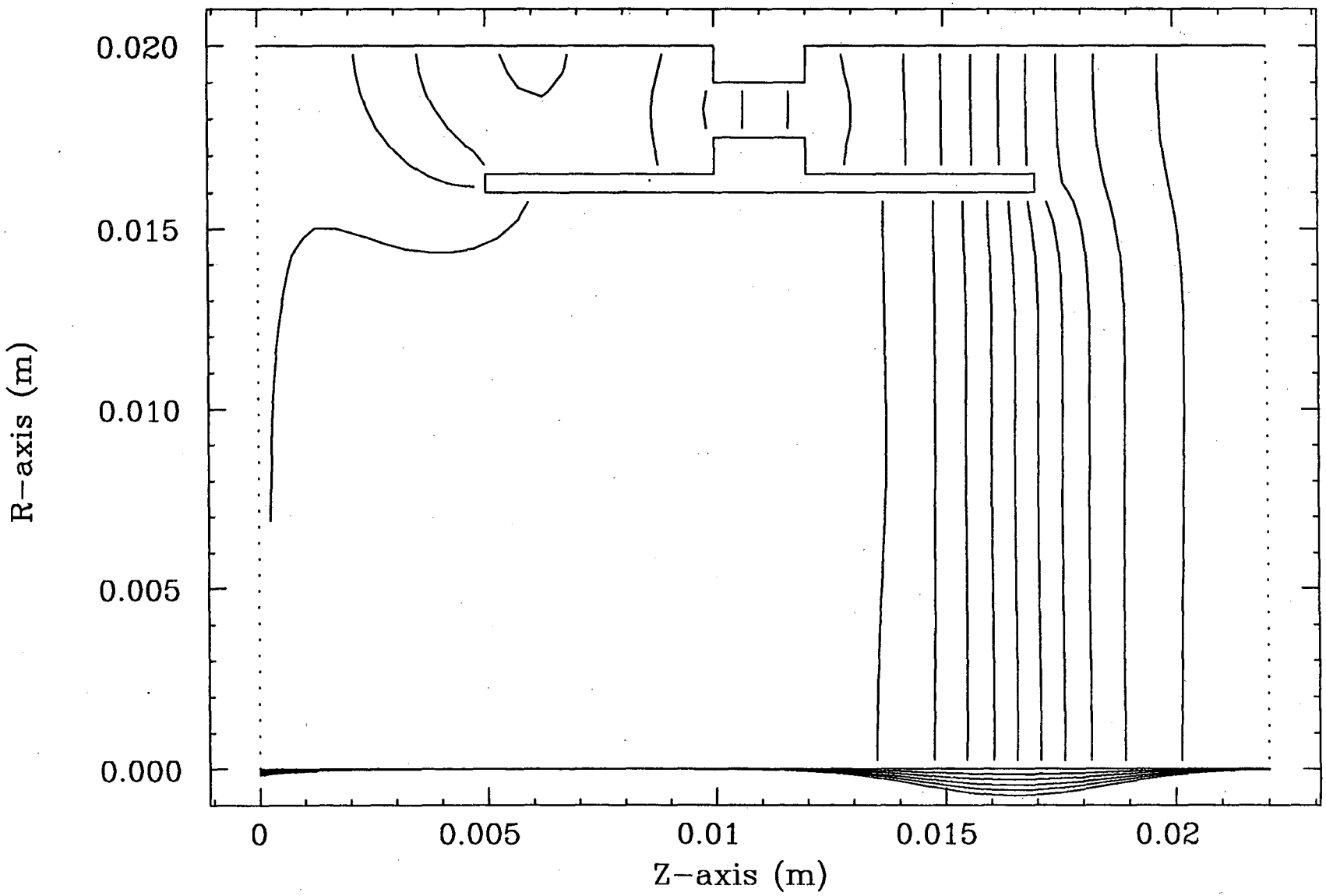

Electric Field Lines
Time Passed: 59.49 (ps)
10/03/94 20.28.42
A B C I 8.8 : SAMPLE INPUT #3 A MONITOR-LIKE STRUCTURE WITH A CUTTING EDGE
SIG= 0.200 cm, Min/Max= 2.500E-02/ 4.750E-01(C), Flux Between Lines= 5.000E-02(C)
0.020
0.015
0.010
0.005
0.000
R-axis (m)
0
0.005
0.01
0.015
0.02
Z-axis (m)

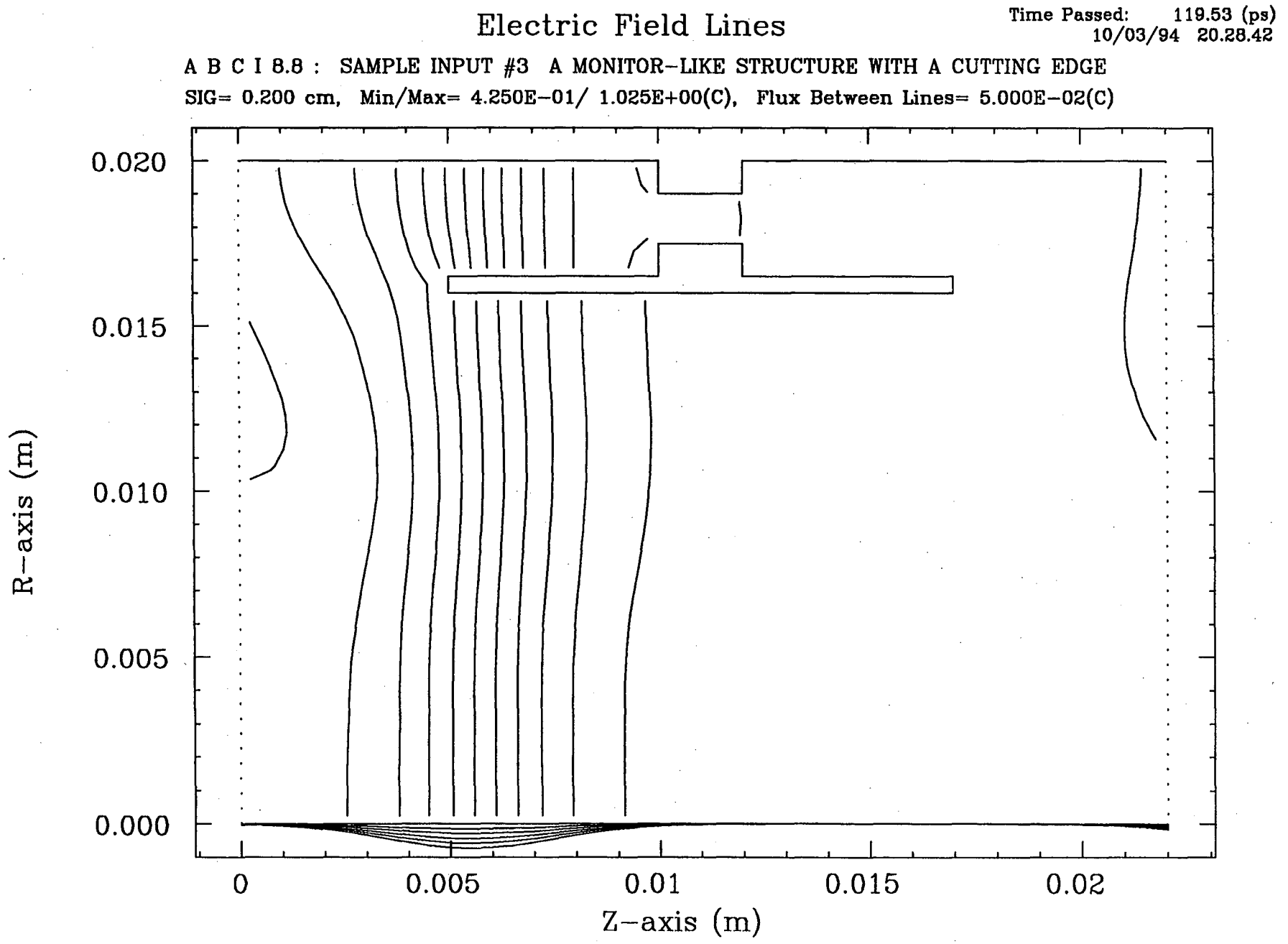
Electric Field Lines

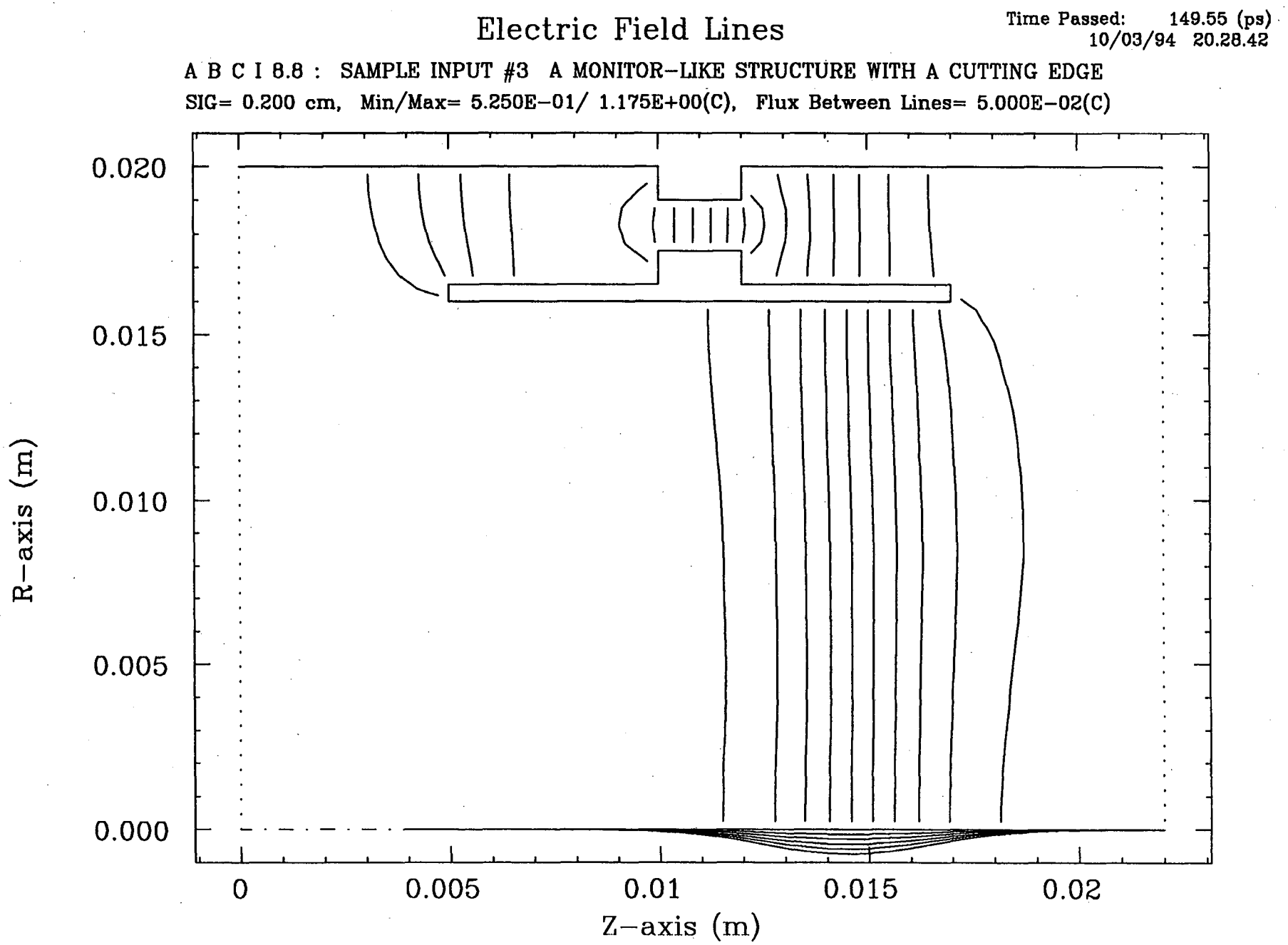
Time Passed: 89.51 (ps)
10/03/94 20.28.42

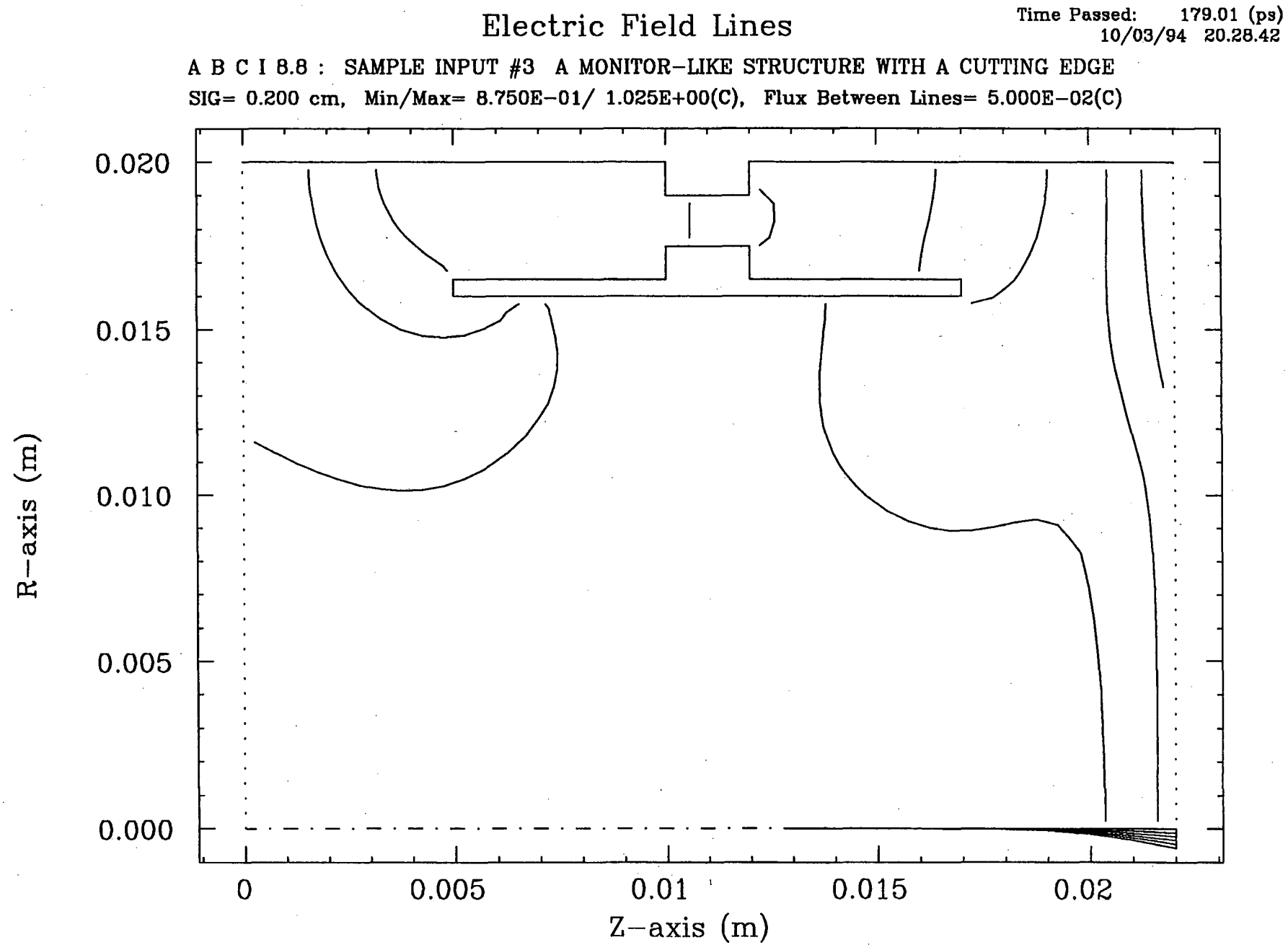
A B C I 8.8 : SAMPLE INPUT #3 A MONITOR-LIKE STRUCTURE WITH A CUTTING EDGE

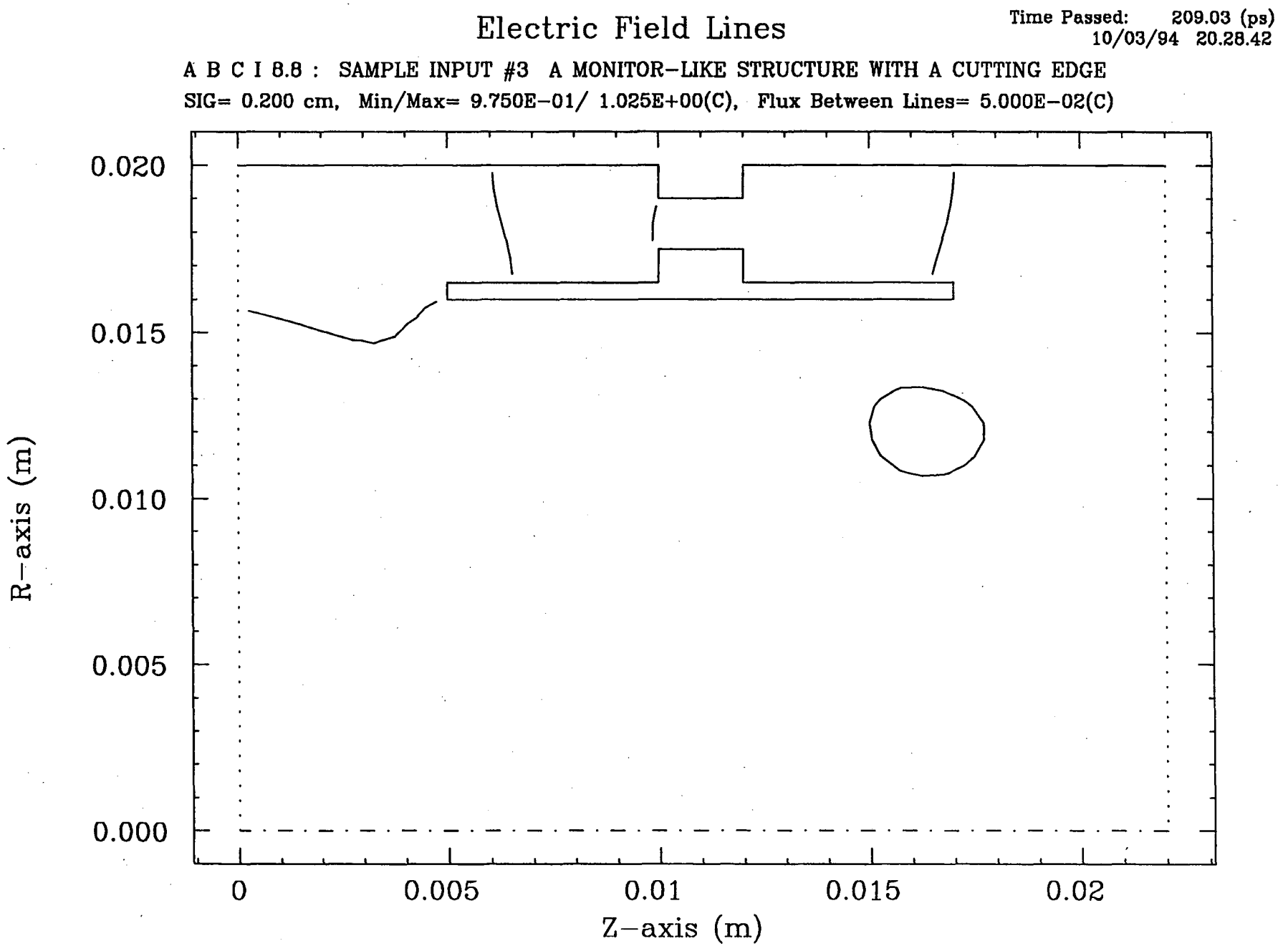
SIG= 0.200 cm, Min/Max= 2.500E-02/ 6.750E-01(C), Flux Between Lines= 5.000E-02(C)

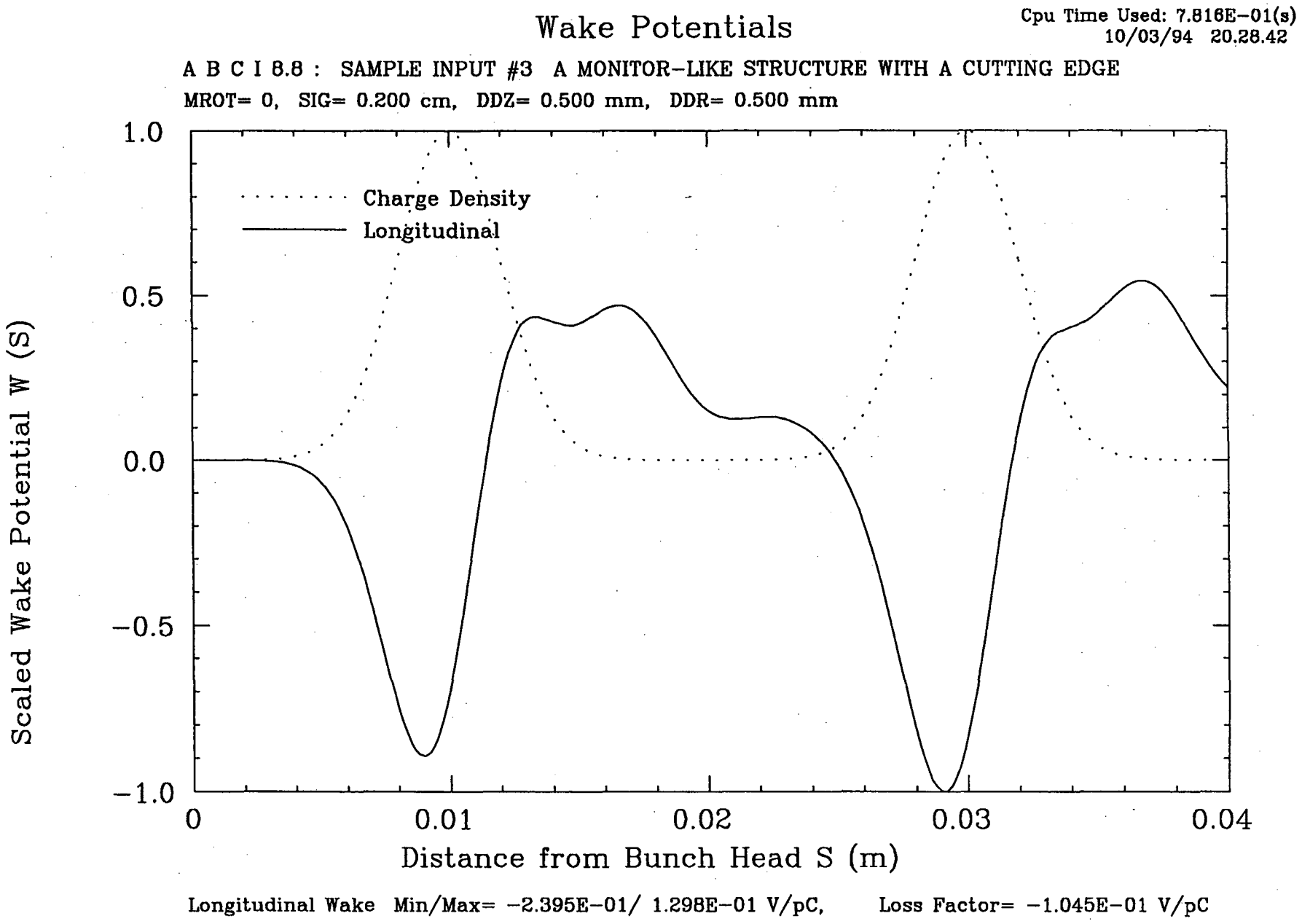



Electric Field Lines
Time Passed: 119.53 (ps)
10/03/94 20.28.42
A B C I 8.8 : SAMPLE INPUT #3 A MONITOR-LIKE STRUCTURE WITH A CUTTING EDGE
SIG= 0.200 cm, Min/Max= 4.250E-01/ 1.025E+00(C), Flux Between Lines= 5.000E-02(C)
0.020
0.015
0.010
0.005
0.000
R-axis (m)
0
0.005
0.01
0.015
0.02
Z-axis (m)


Electric Field Lines
Time Passed: 149.55 (ps)
10/03/94 20.28.42
A B C I 8.8 : SAMPLE INPUT #3 A MONITOR-LIKE STRUCTURE WITH A CUTTING EDGE
SIG= 0.200 cm, Min/Max= 5.250E-01/ 1.175E+00(C), Flux Between Lines= 5.000E-02(C)
0.020
0.015
0.010
0.005
0.000
R-axis (m)
0
0.005
0.01
0.015
0.02
Z-axis (m)


Electric Field Lines
Time Passed: 179.01 (ps)
10/03/94 20.28.42
A B C I 8.8 : SAMPLE INPUT #3 A MONITOR-LIKE STRUCTURE WITH A CUTTING EDGE
SIG= 0.200 cm, Min/Max= 8.750E-01/ 1.025E+00(C), Flux Between Lines= 5.000E-02(C)
0.020
0.015
0.010
0.005
0.000
R-axis (m)
0
0.005
0.01
0.015
0.02
Z-axis (m)


Electric Field Lines
Time Passed: 209.03 (ps)
10/03/94 20.28.42
A B C I 8.8 : SAMPLE INPUT #3 A MONITOR-LIKE STRUCTURE WITH A CUTTING EDGE
SIG= 0.200 cm, Min/Max= 9.750E-01/ 1.025E+00(C), Flux Between Lines= 5.000E-02(C)
0.020
0.015
0.010
0.005
0.000
R-axis (m)
0
0.005
0.01
0.015
0.02
Z-axis (m)


Wake Potentials
Cpu Time Used: 7.816E-01(s)
10/03/94 20.28.42
A B C I 8.8 : SAMPLE INPUT #3 A MONITOR-LIKE STRUCTURE WITH A CUTTING EDGE
MROT= 0, SIG= 0.200 cm, DDZ= 0.500 mm, DDR= 0.500 mm
Charge Density
Longitudinal
1.0
0.5
0.0
−0.5
−1.0
Scaled Wake Potential W (S)
0
0.01
0.02
0.03
0.04
Distance from Bunch Head S (m)
Longitudinal Wake Min/Max= −2.395E−01/ 1.298E−01 V/pC, Loss Factor= −1.045E−01 V/pC

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