 IEEE Transactions on Nuclear Science, Vol. NS-30, No. 4, August 1983

DISK-AND-WASHER LINAC STRUCTURE WITH BIPERIODIC T SUPPORTS*

Y. Iwashita,† AT-DO, MS H811
Los Alamos National Laboratory, Los Alamos, NM 87545

Summary

The disk-and-washer (DAW) linac structure with particular biperiodic washer-support geometries promises to be an excellent structure for ß > 0.5 accelerator applications. Outstanding features of this structure include high efficiency, high stability, good vacuum properties, and ease of fabrication.[1]

Introduction

Early enthusiasum for this structure was dampened somewhat by the discovery of an overlap between a TM_{11}-like (hereafter called TM_{11}) passband, known as the deflecting mode passband, and the operating frequency.[2] Some solutions to this intolerable situation had to be found before this structure could receive further consideration for electron applications.[3] I have found the biperiodic washer supports in the 4-T configuration to be an effective means of modifying the TM_{11} passband so that it no longer crosses the operating frequency and threatens the performance of this structure for electron applications.[4] Much was learned in recent months from systematic studies of the rf cavity mode spectra in four aluminum DAW test cavities, built originally for the PIGMI program, corresponding to ß = 0.5, 0.6, 0.7, and 0.8.[5] Two additional test cavities were fabricated at ß = 1.0. All six cavities were scaled to operate at 2380 MHz.

All of the washer support geometries were of the biperiodic-T variety, where pairs of washers are supported by one or more Ts in some azimuthal arrangement. The smaller of the two ß = 1.0 cavities is a direct extension of the PIGMI geometries. The larger cavity is 5% larger in the cavity radius. The data presented here are restricted to a No-T configuration and two biperiodic T-support geometries: 2Ts (at 180°) and 4Ts (at 90°). The Ts are designed so as to have a minimum perturbation to the accelerating mode.

There are several other options for the azimuthal arrangement of the Ts in the 2-T structure: 2-Ts at 90°, lined up with adjacent supports; and 2-Ts at 180°, rotated 90° from adjacent supports. The latter two options are difficult to study in the laboratory because of cavity termination problems. A modification of these options, where two sets of supports for four washers are in line and rotated from the adjacent sets of supports, can be terminated at planes of symmetry. But no useful results on the TM_{11} passbands were obtained because there were not enough cells to exhibit the octaperiodic behavior. The first option does not look good. The amount of perturbation is about half that of the 4T scheme, and it is difficult to avoid both the TM_{11} and TE_{31} passbands. The other option will be studied at a later date.

Mode Spectra

The resonant frequency of the following cavity modes are measured in each of the six test cavities for different washer support geometries: TM_{01}, TM_{02}, TM_{11}, TM_{21}, TE_{11}, TE_{21}, TE_{31}.

*Work supported by the US Department of Energy.
†Los Alamos National Laboratory and Institute for Chemical Research, Kyoto University, Kyoto, Japan.

The No-T measurements were made in the two half-cell configurations with half-washers at each end. Only the TM_{010}, $TM_{01\pi}$, TM_{110}, $TM_{11\pi}$ and TM_{020} passbands were measured in these small cavities. Figure 1 shows these modes and the associated passbands as a function of beta. These results are in excellent agreement with the SUPERFISH design calculation. This agreement and additional results from ULTRAFISH, which is still under development at Los Alamos, are shown in Table I. The measured mode-spectra structure in the 2-T and 4-T configuration are shown in Figs. 2-7. The washer supports have an appreciable effect on the frequencies of some of the cavity modes.

The operating mode in each case is 2380 MHz and corresponds to the $TM_{02\pi}$ mode. The DAW coupling mode corresponds to the $TM_{01\pi}$ mode and is designed to be close to the operating frequency.

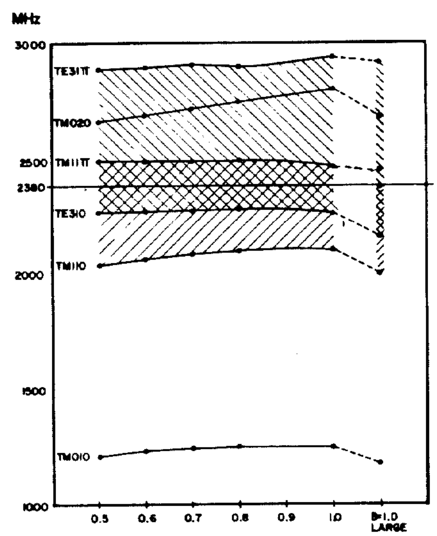

Fig. 1. The range of unperturbed passband measured in the two half-cell configuration.

TABLE I

COMPARISON OF CALCULATED WITH MEASURED RESULTS

	ß = 1.0 Small Experimental MHz	Calculated MHz	ß = 1.0 Large Experimental MHz	Calculated MHz
TM_{010} [a]	1247.8	1251.5	1184.2	1190.7
$TM_{01\pi}$ [a]	2374.6	2379.9	2376.2	2380.[illegible]
TM_{020} [a]	2802.2	2812.8	2679.2	2695.3
$TM_{02\pi}$	2389.7	2380.0	2381.7	2376.0
TM_{110} [a]	2104.1	2105.0	1997.8	1999.0
$TM_{11\pi}$ [a]	2454.3	2463.5	2444.1	2455.0
TE_{310} [b]	(≈2270)	2278.9	(≈2160)	2173.0
$TE_{31\pi}$	2937.5	2900.0	2914.3	2983.6

The axisymmetric modes were calculated by SUPERFISH. The others were done by ULTRAFISH.

[a] These mode data are measured in No-T configuration. Others are with 2-T configuration.

[b] TE_{310} modes are not measured, but extrapolated from measured points, because they are forbidden by the end plates.

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TM_{11} Mode

Figures 2-7 show many modes in the mode spectra between 1 and 3 GHz. Most of these modes are of little concern. The modes of most concern are those in the TM_{11} passband. These are known to cause beam-deflection problems in some applications. The TM_{11} passband in the unperturbed condition has the unacceptable property of crossing the operating frequency. The necessary washer supports, however, represent significant perturbations to a number of the cavity passbands. It has been shown that the biperiodic 4-T washer-support configuration has a favorable effect on the TM_{11} passband in this respect. The biperiodic T-support splits the TM_{11} passband into two narrow passbands separated by a wide (300-MHz) stop band. In all six geometries studied, the DAW operating frequency falls well within this stop band. The 4-T configuration has only the perturbed passbands and no trace of the unperturbed passband. It is now clear that the 4-T configuration is superior to the 2-T (in-line) configuration in cases where the deflecting modes are of concern.

TE_{31} Mode

The TE_{31} passband crosses the operating frequency in some of these geometries. The principal reason for building the larger β = 1 cavity was to lower the TE_{31} so that it would not cross the operating frequency. The biperiodic 4-T-support configuration introduces a stop band in this mode and eliminates the unperturbed passband of this mode. The 3-T configuration does not result in this degeneracy. Hence, the 4-T configurations is superior to the 2-T and 3-T configurations in this respect as well.

Conclusion

It has been demonstrated that T-supports modify the TM_{11} (and other) passbands, and it is suggested that the larger β = 1.0 geometry in the 4-T configuration is an excellent candidate for electron-linac applications, including those involving recirculation. Because the β dependence is small, this geometry can be extended to lower β values for ion application.

Acknowledgment

The author thanks D. A. Swenson for time spent in constructive discussions and for his continuous encouragement. He also thanks R. A. Jameson and J. M. Potter for their support.

References

1. L. D. Hansborough, Compiler, "PIGMI: A Design Report for a PIon Generator for Medical Irradiations," Los Alamos National Laboratory report LA-8880 (September 1981).
2. L. M. Young and J. M. Potter, "Deflecting Modes in the DAW Structures," Los Alamos National Laboratory, Accelerator Technology Division, Group AT-1 memorandum AT-1:82-59 (March 17, 1982).
3. R. K. Cooper, Y. Iwashita, J. M. Potter, S. O. Schriber, D. A. Swenson, J. M. Watson, L. C. Wilkerson and L. M. Young, "Radio-Frequency Structure Development for the Los Alamos/NBS Racetrack Microtron," Los Alamos National Laboratory document LAUR-83-95 (January 1983).
4. Y. Iwashita, "RF Cavity Mode Spectra Measurement in the Disk-and-Washer Linac Structure," Los Alamos National Laboratory, Accelerator Technology Division, AT-DO memorandum AT-DO:YI-243 (July 21, 1982).
5. D. A. Swenson and J. M. Potter, "Test Cavities for PIGMI DAW Structure," Los Alamos Scientific Laboratory, Accelerator Technology Division, AT-DO memorandum to Distribution (June 23, 1980).

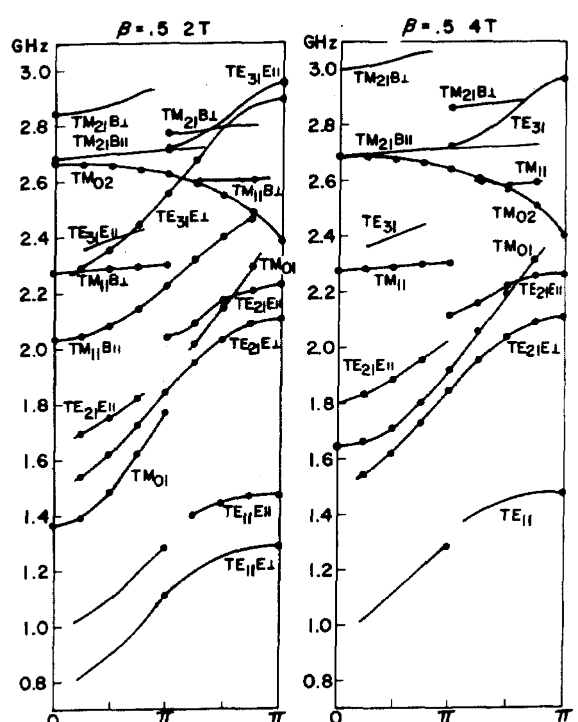

Fig. 2. Mode spectra for β = 0.5 PIGMI test cavity.

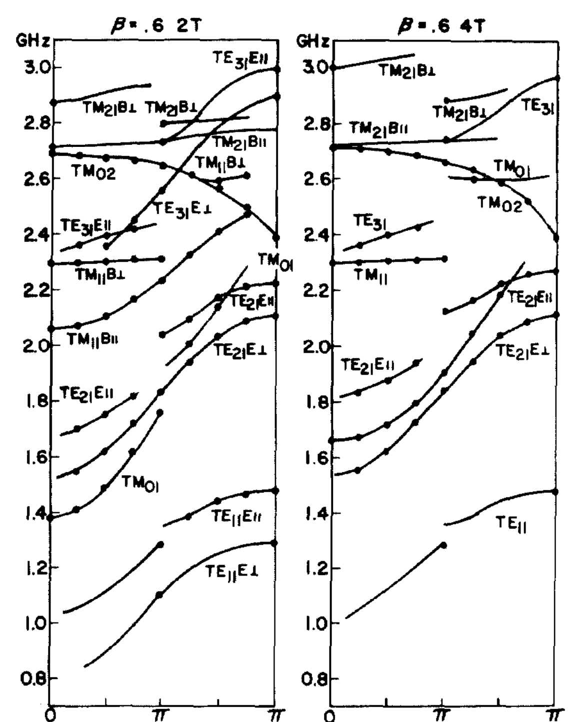

Fig. 3. Mode spectra for β = 0.6 PIGMI test cavity.

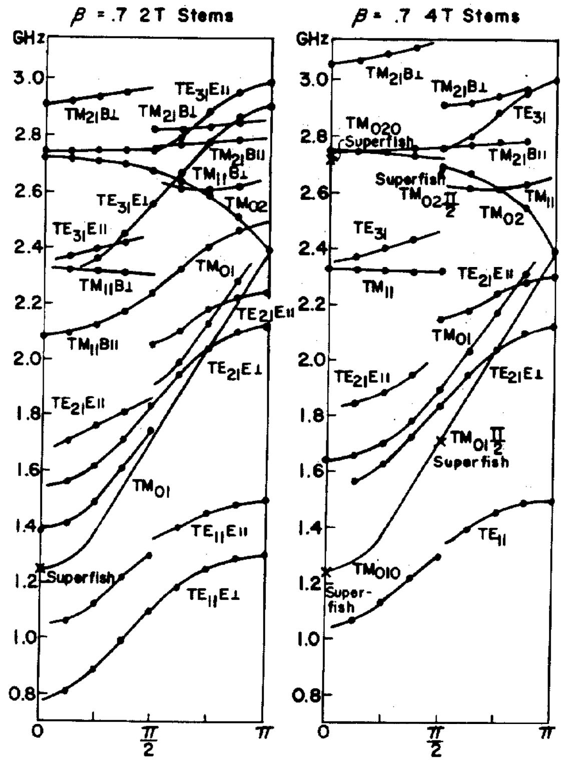

Fig. 4. Mode spectra for β = 0.7 PIGMI test cavity.

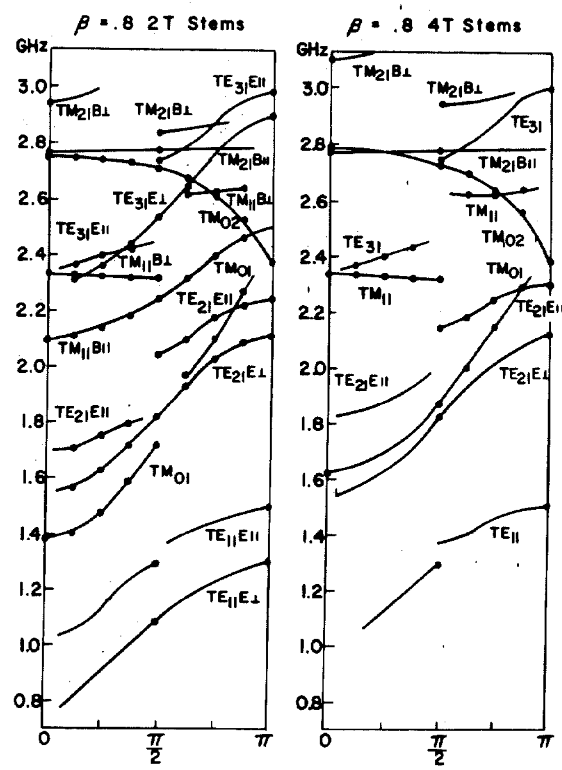

Fig. 5. Mode spectra for β = 0.8 PIGMI test cavity.

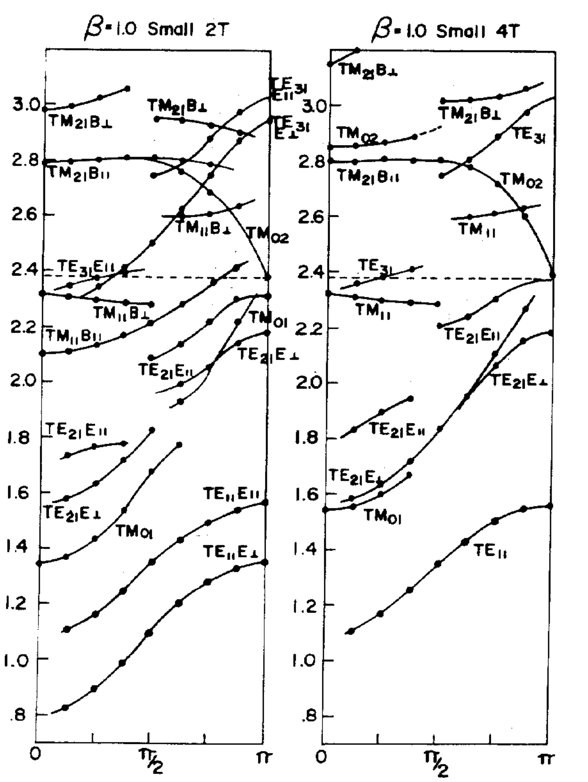

Fig. 6. Mode spectra for β = 1.0 small cavity, which is direct extension of PIGMI geometries.

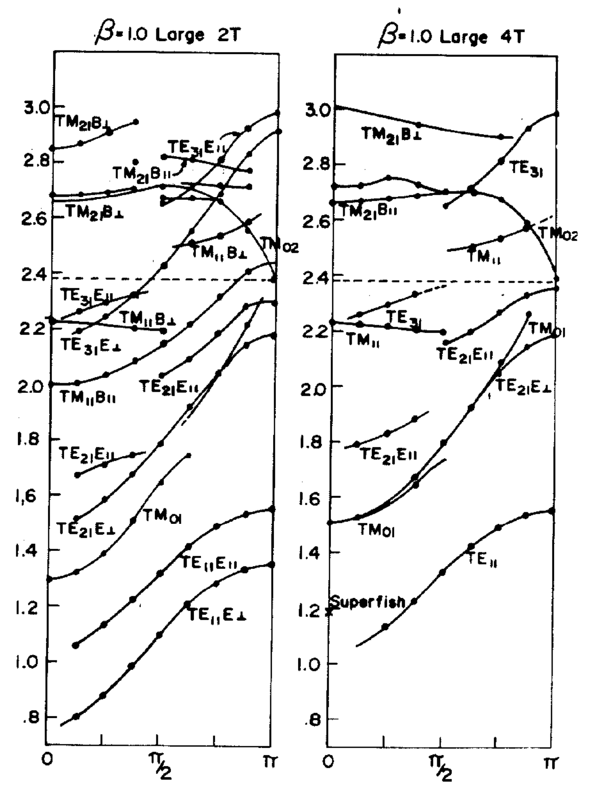

Fig. 7. Mode spectra for β = 1.0 large cavity, which is 5% larger in the cavity radius than PIGMI geometries.