HIGH EFFICIENCY LINEAR ACCELERATOR STRUCTURE

I. Sato, Y. L. Wang, K. Nakahara, A. Enomoto, S. Ohsawa
S. Anami, T. Urano, H. Kobayashi, T. Kamitani, K. Konnashi* and S. Toyama*

National Laboratory for High Energy Physics
1-1 OHO, TSUKUBA-SHI, IBARAKI-KEN, 305 JAPAN

* Power Reactor and Nuclear Fuel Development Corporation, Tokai Works
3371 MURAMATSU, TOKAI-MURA, NAKA-GUN, IBARAKI-KEN, 319-11 JAPAN

ABSTRACT

A new type of traveling wave linear accelerator structure has been studied. This accelerator structure has high shunt impedance, high group velocity, high Q value and low attenuation. Therefore, this structure with traveling wave resonant ring has high efficiency. Specially, for large beam current or CW linac, the accelerator efficiency can reach as high as 90%.

The theoretical study has been performed using of computer codes SUPERFISH and MAFIA. Some experiment results have been got. It shows that the results of calculation by SUPERFISH code agree with results of experiments.

1. Structure and calculation

It is well known that for a disk-loaded accelerator structure parameters of shunt impedance R, group velocity Vg, Q value and attenuation α are functions of apeature 2a. They are shown on Fig. 1. If one wants to reduce apeature 2a to very small to get high R, it is impossible because of Vg and α changing such rapidly that the energy can not propagate from one cell to the next cell. Our idea is that we punch some coupling slits on disks side to increase coupling. It makes the structure have high shunt impedance R, high Q value, high group velocity Vg and low attenuation α. Its parameters and structure are shown on Fig. 2 and Fig. 3. These parameters are calculated by SUPERFISH cord.

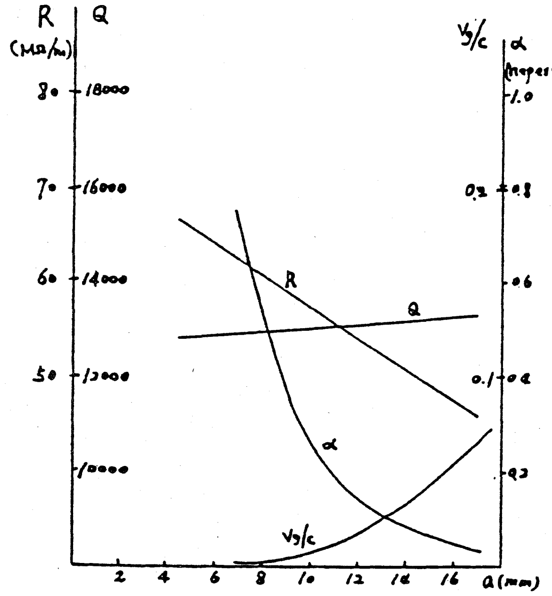


Fig. 1 Parameters for disk-loaded

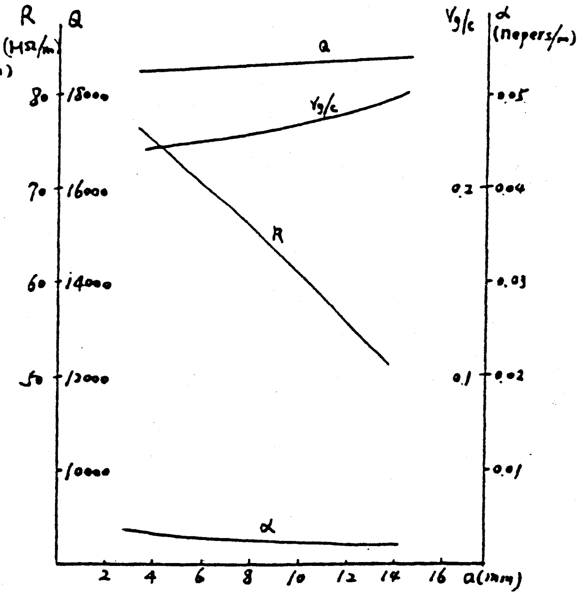
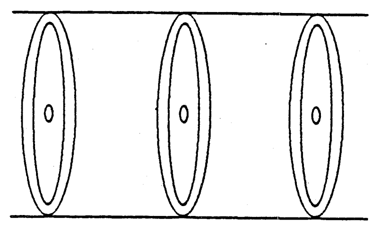
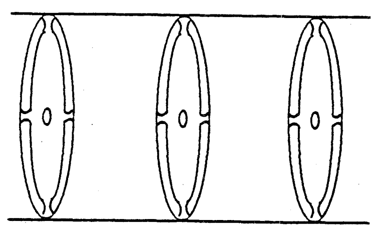


Fig. 2 Parameters for HELAS

Fig. 4 shows the parameters as functions of the width of the coupling slits Δr. We can see that when Δr increasing, Vg and Q increase, α decrease and R is constant.



Type (a)



Type (b)

Fig. 3 Structure of HELAS

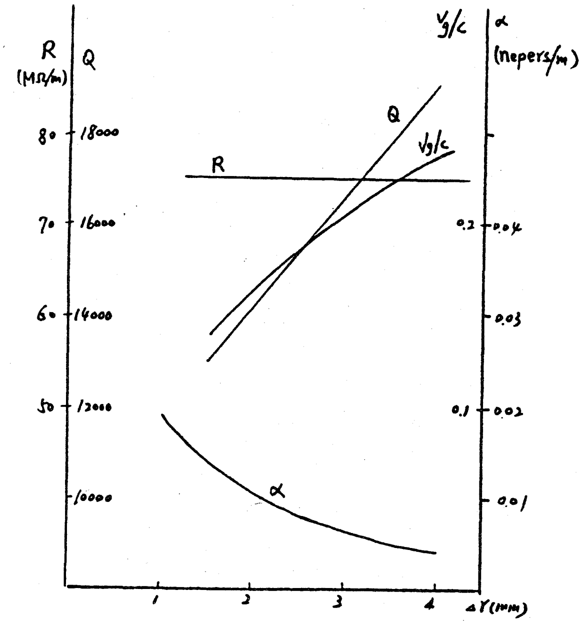


Fig. 4

Because SUPERFISH code can not calculate the three-dimension cavity shown on Fig. 3 type (b), we use MAFIA code to calculate these cavities. In order to compare we calculate three cavities. The results are shown on Fig. 5 and Table 1. We can see that There are some differences between results using two codes calculation. According to MAFIA calculation shunt impedance R, group velocity Vg and Q value are lower than that by SUPERFISH calculation. But we can know that type (a) structure only has forward wave modes, and type (b) structure has forward wave and backward wave modes.

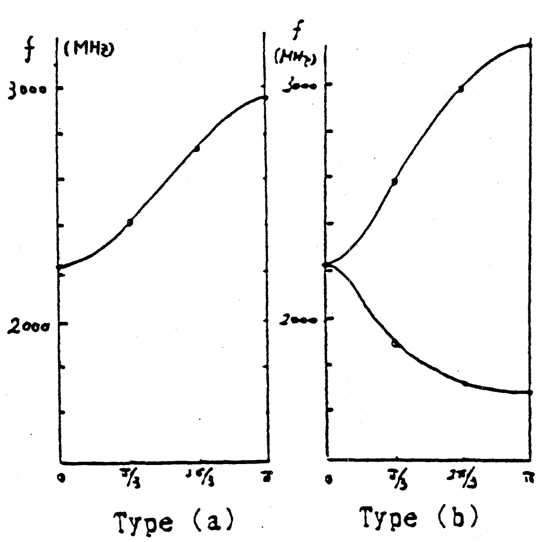


Fig. 5 Brillouin diagram

Table 1

Type				Code
Vg/C	0. 2348 0. 1904	 0. 24	0. 0078 0. 0035	(FISH) (MAFIA)
R (MΩ/m)	75. 1 51. 3	 33. 5	62. 2 51. 5	(F) (M)
Q	18510 12200	 12340	13960 9990	(F) (M)
α (neper/m)	0. 0069 0. 0124	 0. 0103	0. 23 0. 86	(F) (M)

2. Experiment.

A set of test cavities have been manufactured. We measure frequencies of various modes, the ratio of shunt impedance to Q value and Q value. Brillouin diagram is shown on Fig. 6. The experiment curve is very close with the curve calculated by SUPERFISH. The Fig. 7 shows the field distribution on the axis, by means of the frequency perturbation caused by a bead drawn along the axis of the test cavities. This field can be decomposed by Frourier analysis into its components, then we can get fundamental harmonic. There are two methods for determining the absolute value of the electric field. For some simple shapes, such as a metallic sphere it can be determined theoretically; or it can be found experimentally by inserting the perturbing object into a cavity with known fields and measuring the resultant frequency change.

The results of experiment and calculation by two codes are shown on the Table 2. From the table we can see that R0/Q and Vg/c measured are agreeable to that calculated by SUPERFISH code, but Q value measured is so low in comparison with the value of calculation. We think that in our test cavities, we use acryl resin to support the disks, it makes Q value down due to dielectric loss. If we use ceramic support it will get high Q value.

3. Discussion

If we use this accelerator structure with traveling wave resonant ring, we can design a CW accelerator, its efficiency can get as high as 90%. This is very useful. So we call this accelerator structure HELAS (High Efficiency Linear Accelerator Structure).

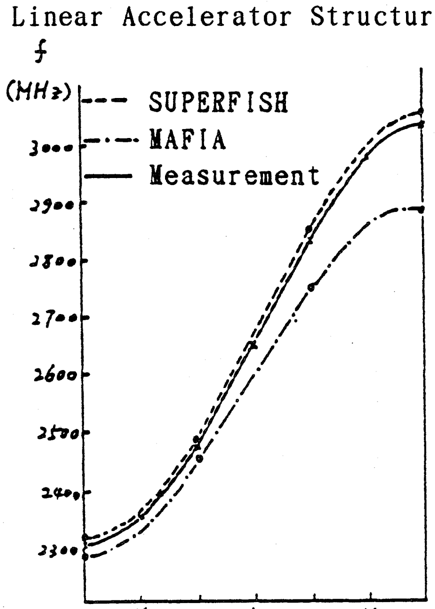


Fig. 6

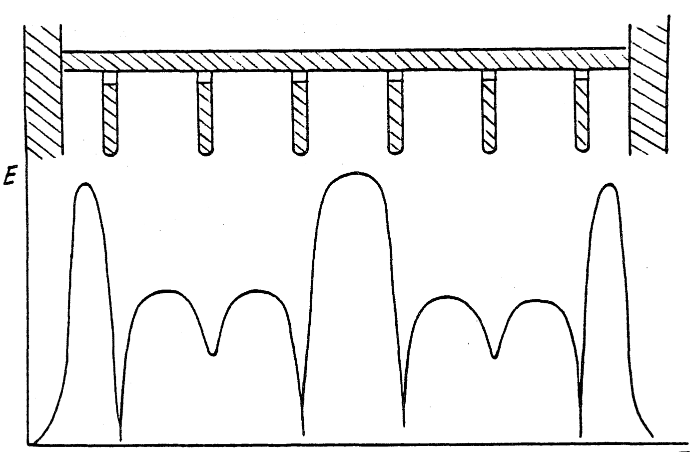


Fig. 7 Field distribution by frequency perturbation

Table 2

	Ro/Q (Ω/m)	Vg/c	Q
SUPERFISH	4057.2	0.2348	18510
MAFIA	4204.9	0.1924	12200
Measurement	3982.9	0.2300	9000