DEVELOPMENT OF AN RFQ MODEL CAVITY IN KEK

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ABSTRACT

An RFQ model cavity at a frequency of 200 MHz was constructed using a computer program developed at KEK. A detailed study of rf characteristics was performed. The fundamental properties of accelerating and focusing field distributions and the resonant frequency agree well with the design values.

The successful acceleration of beam by an RFQ linac at Los Alamos National Laboratory in 1980[1)] generated great interest in an RFQ linac as the pre-accelerator for a linac because it is very much simpler and smaller than the Cockcroft-Walton accelerator.

Polarized proton beam or H^- beam injection into the Booster Synchrotron is scheduled in the near future at KEK. The beam intensity of the polarized protons ($\sim$ 10 μA) is smaller than the current beam by four orders of magnitude and that of the H^- ($\sim$ 10 mA) by one order. Therefore an RFQ linac, whose maximum current is limited by space charge to the rather small value of > 10 mA is suitable for the acceleration of both beams.

The aluminum model cavity (Fig. 1) was designed with the computer program "QKEK" which can generate an RFQ linac, calculate beam dynamics, and provide the geometrical data for the production of two kinds of modulated vanes on a tape-controlled milling machine. The cavity length of 62 cm was determined by ease of construction and cost of fabrication. The parameters of the model cavity are shown in Table 1. The accelerating field increases linearly with distance in order to facilitate the comparison of measurement and theory. Three kinds of vanes were machined. Two of them are straight ones with pole tip radius of 5 mm and 6 mm. The other is modulated with the modulation increasing monotonously from 1 to 2. The modulated vane consists of three different structures: the matching, bunching, and acceleration sections.

The resonant frequency and Q-values obtained are shown in Table 2. The mode separation between TE210-like and TE110-like modes is large enough to avoid the excitation of both as seen in Fig. 2. The measured resonant frequency agrees with the results of SUPERFISH within 0.9 %.

The axial field was measured by the bead perturbation method using a self-excited oscillator. The result is shown in Fig. 3. Although the bead used is small (2 mm in diameter and 3 mm in length), the contribution from the radial and azimuthal electric fields, E_r and E_ϕ, can be ignored. In Fig. 3 the solid line represents $\int(E_z^2 + E_r^2 + E_\phi^2)dv$ and the dashed line is resulting estimate of $\int E_z^2 dv$. The distribution of the axial field is shown in Fig. 4. We see that the desired field can be realized with the modulated vanes.

Figure 5 shows the results of the azimuthal field measurements with the 6 mm straight vanes using bead perturbation methods.

REFERENCE

1) R.W. Hamm et al., Second International Conference on Low-energy Ion Beams (1980) p.54.

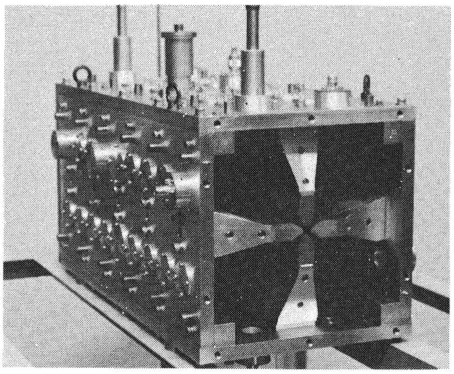

Fig.1 RFQ model cavity.

Frequency	201.08	MHz
Injection energy	50	kev
Final energy	153	kev
Vane voltage	22	kv
Number of cells	66	
Length	61.5	cm
Initial radius	2.3	cm
Minimum radius	0.4	cm
Initial modulation	1.0	
Final modulation	2.0	
Initial phase	-90°	
Final phase	-30°	

Table 1 Parameters of the model cavity.

Table 2 Measured resonant frequency and Q-values.

	TE210		TE110	
	f_0	Q_0	f_{01}	f_{02}
5 mm vane	198.4	4300	218.6	221.1
6 mm vane	209.1	4900	218.5	219.5
modulated vane	211.1	4400	218.6	221.1

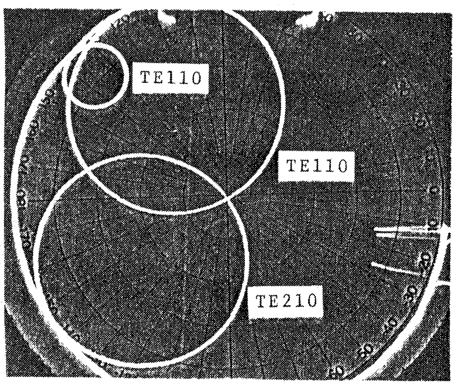

Fig.2 Resonant modes on polar display.

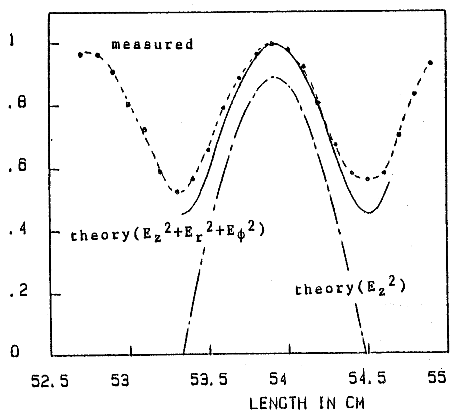

Fig.3 Measured axial field.

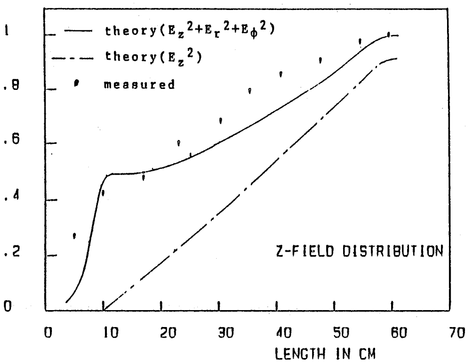

Fig.4 Distribution of the axial field.

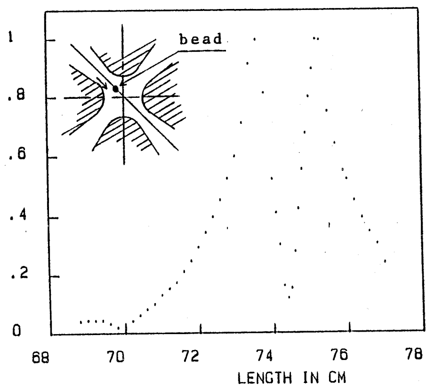

Fig.5 Measured azimuthal field.